Air Force Civil Engineer Center

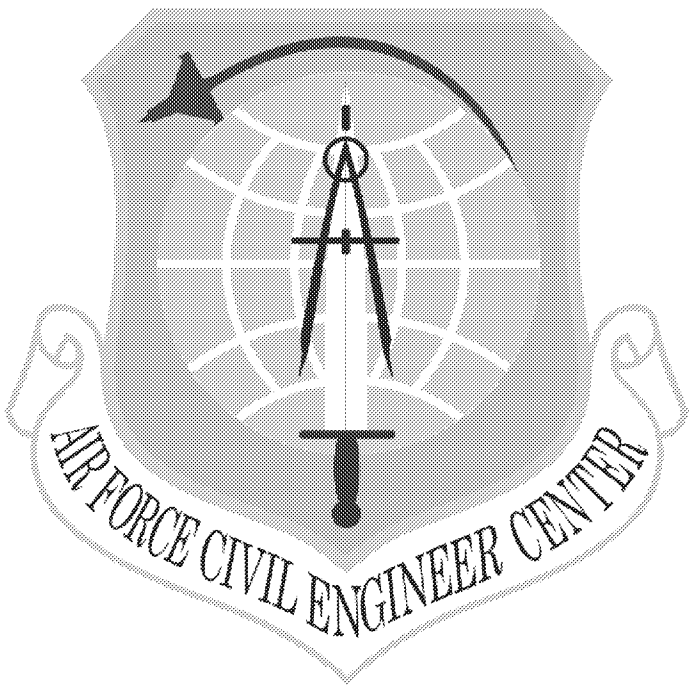
Integrity - Service - Excellence

Former Williams Air Force Base

BRAC Cleanup Team Call
15 October 2015

Air Force Civil Engineer Center

Integrity - Service - Excellence



FORMER
WILLIAMS AIR FORCE BASE

Site ST012
Former Liquid Fuels Storage Area Remedial Action

BRAC Cleanup Team Call
15 October 2015

Site ST012 Update

- Steam Enhanced Extraction (SEE) Operations Progress
- Near-term SEE Operational Plan
- SEE to Enhanced Bioremediation (EBR) Transition Criteria Status

SEE System Operational Status Overview

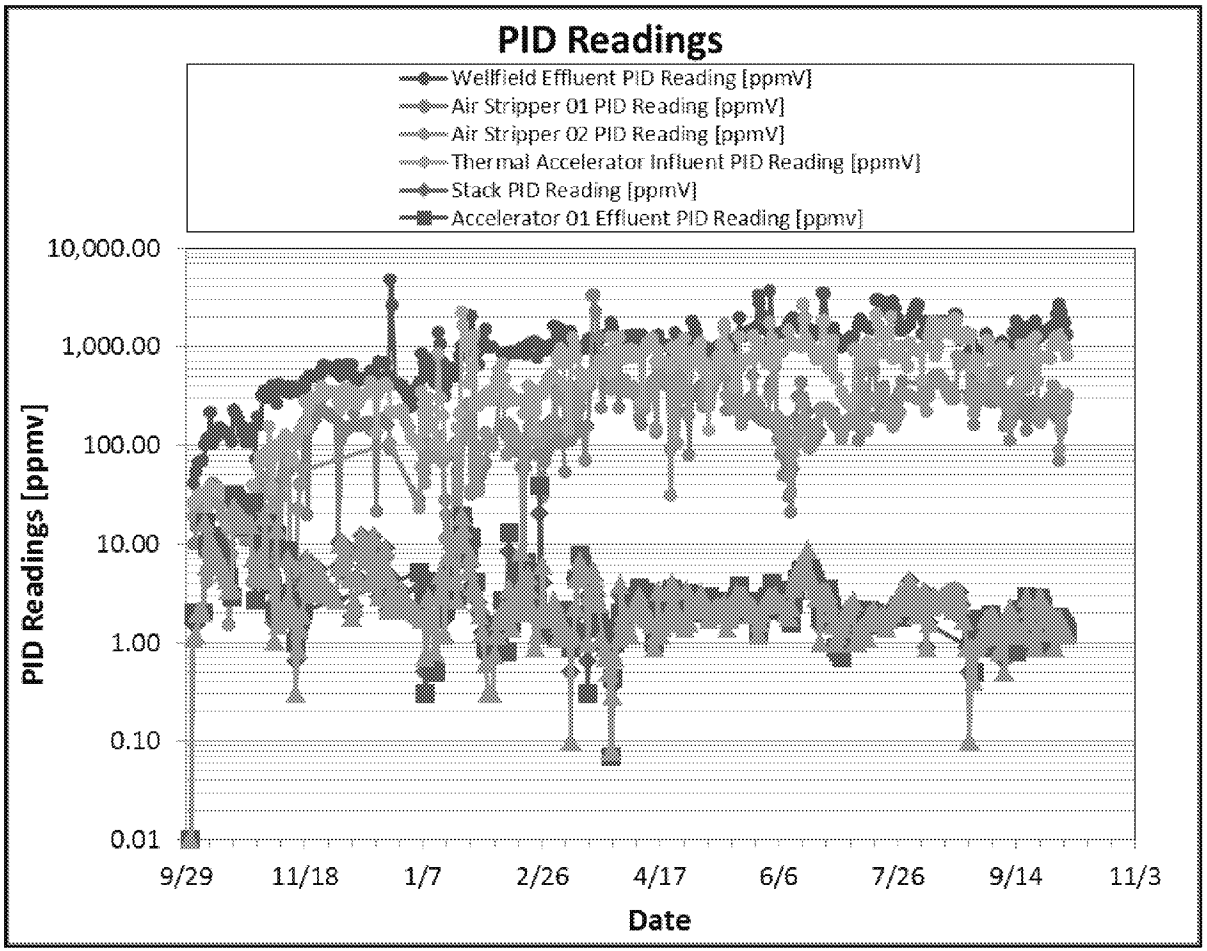
Site ST012 SEE System Status Summary (through 5 October)

	Value	Unit
Target Treatment Zone (TTZ) Soil Volume	410,000	cubic yards (cy)
Area	199,000	square feet (ft^2)
Upper Depth of Treatment	145	feet (ft) below ground surface (bgs)
Lower Depth of Treatment	245	ft bgs
Vapor Liquid Treatment Started	09/29/14	
Thermal Operations Started	09/29/14	
Last Process Data Update	10/05/15	
Last Temperature Data Update	10/05/15	
Estimated Total Days of Operation	422	days
Days of Operation	371	days
Days of Operation vs. Estimate	88	percent (%)
Estimated Total Energy Usage	11,343,000	kilowatt hours (kWh)
Total Energy Used	3,652,943	kWh
Used Electrical Energy vs. Estimate	32	%
Total Steam Injected	228.3	million pounds (lbs)
Projected Total Steam Injection	320	million lbs
Steam Injected Vs Projected	71	%
Total Mass Removed in Vapor Based on Photoionization Detector (PID) Readings	699,078	lbs
Total Mass Removed as NAPL	1,031,501	lbs
Average Daily NAPL Mass Removal Last Week	2,397	lbs/day
Total Vapor and Liquid Mass Removal (based on PID readings)	1,730,578	lbs
Average Power Usage Rate Last Week	475	kilowatts (kW)
Average Wellfield Vapor Extraction Rate Last	383	standard cubic feet per minute (scfm)
Average Condensate Production Rate Last Week	0.5	gallons per minute (gpm)
Average Water Extraction Rate Last Week	91	gpm
Total Water Extracted	57,332,868	gallons
Total Recovered Light Non-Aqueous Phase Liquid	156,763	gallons
Average Water Discharge Rate Last Week	112	gpm
Total Treated Water Discharge	76,065,000	gallons

ST012 SEE Operational Progress

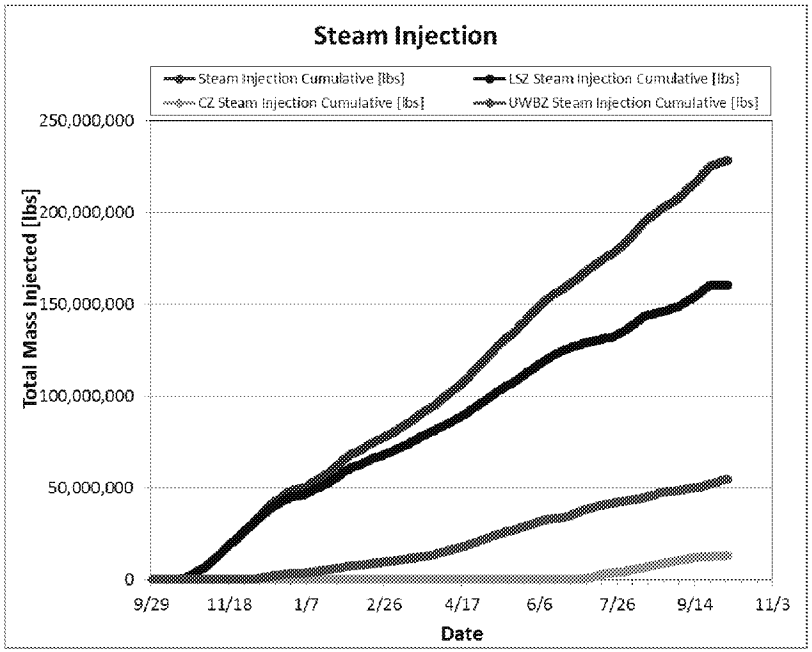
- **SEE System Operations** **8 September – 5 October**
  - Average liquid extraction rate of 97 gpm
  - Typically five to six eductor skids were online at a time
  - Average steam injection rates of 14,500 lbs per hour in the LSZ, 8,400 lbs per hour in the UWBZ, and 3,200 lbs per hour in the CZ
  - Thirty-two steam wells online – injection rates at wells have varied due to pressure cycling conducted in the CZ, LSZ and UWBZ
  - SEE discharge continues to meet compliance standards

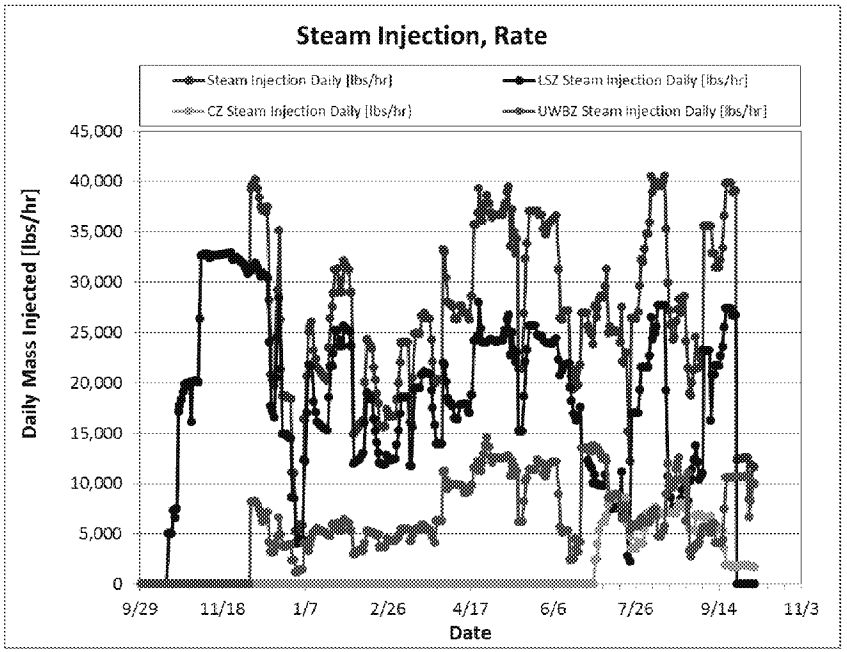
Site ST012 SEE System Photoionization Detector (PID) Readings



Vapors continue to be rich in organics

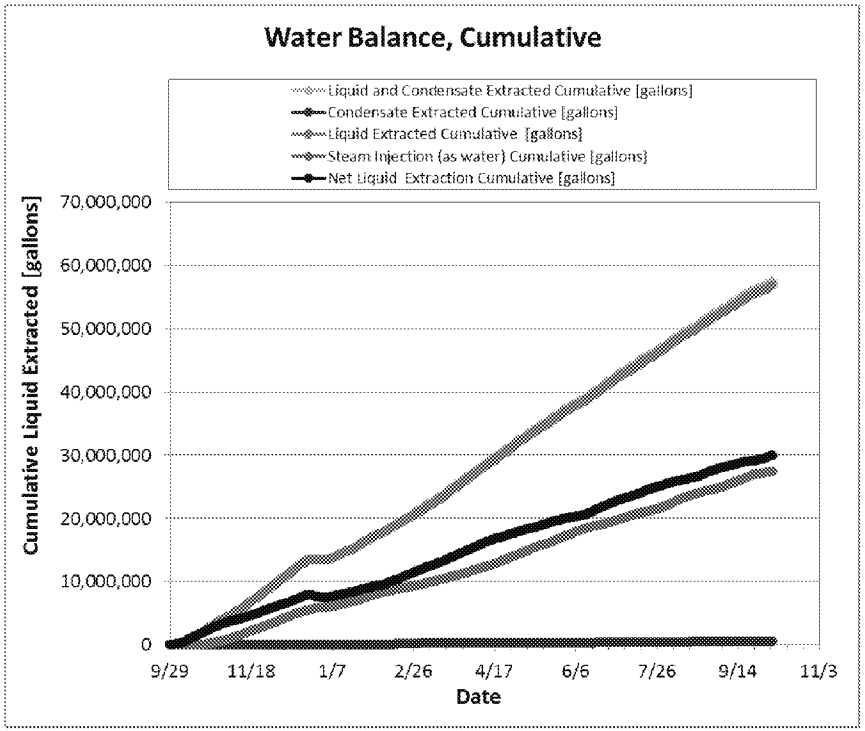
Site ST012 SEE Steam Injection

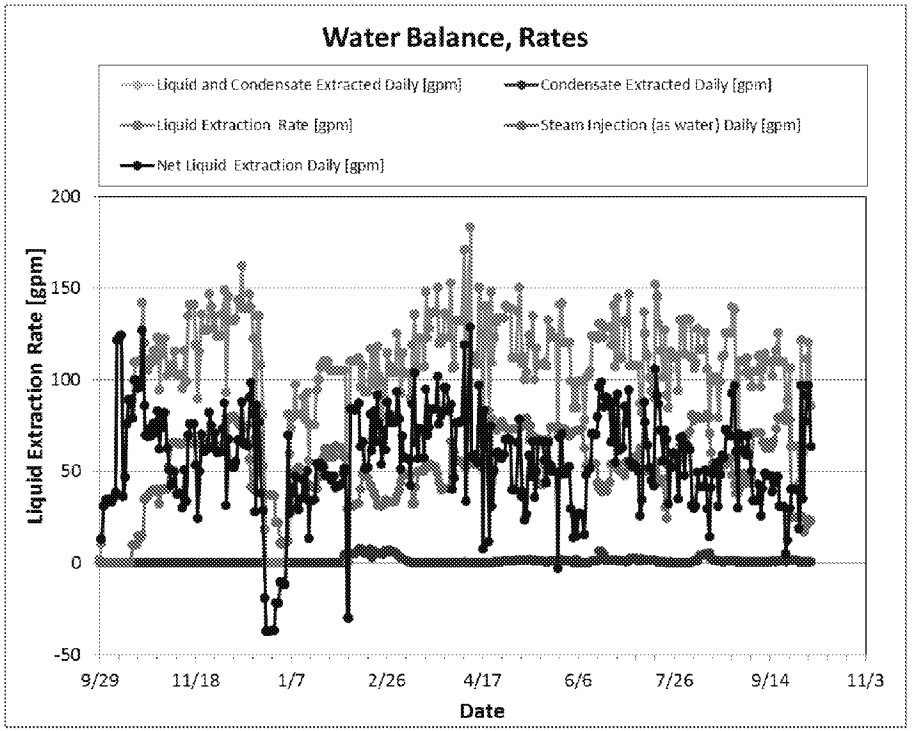




- **Current average steam injection (operational period ending 5 October 2015)**
  - CZ 1,800 lbs/hr ~ 4 gpm as water
  - UWBZ 9,600 lbs/hr ~ 19 gpm as water
  - LSZ 0 lbs/hr ~ 0 gpm as water (offline)
- **Total steam injection rate equivalent to 23 gpm of water**

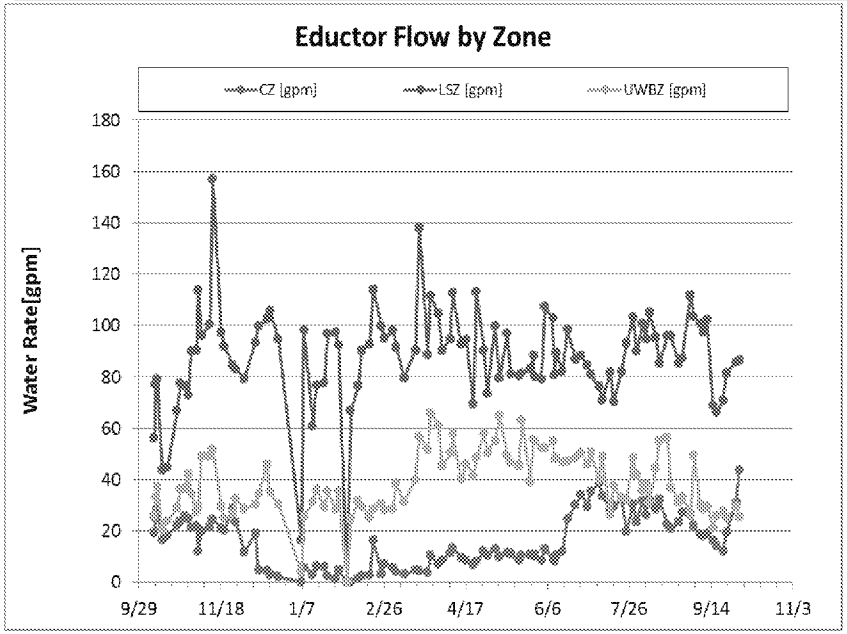
Site ST012 SEE System Water Balance

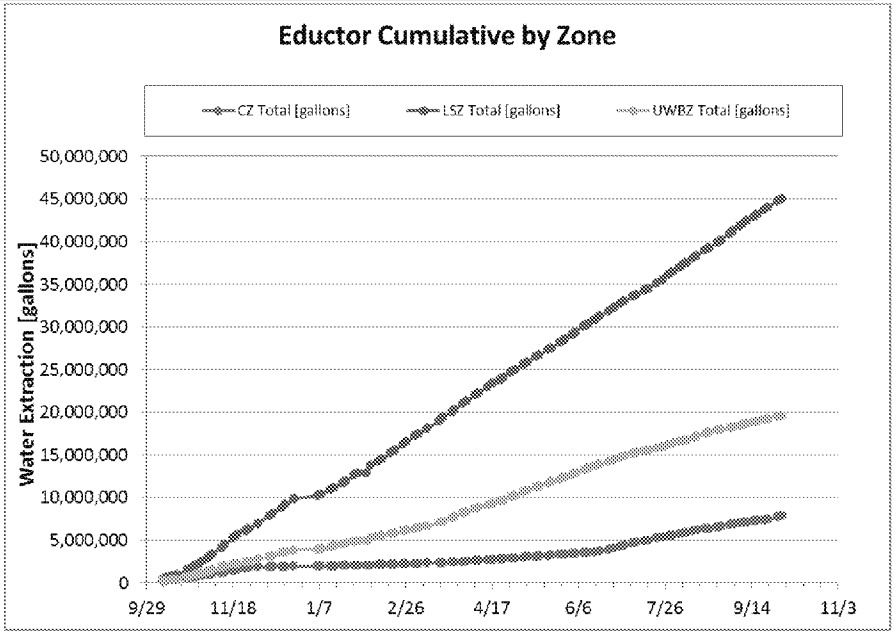




- **Currently, the condensate production rate is ~ 0.5 gpm**
- **Based on energy balance analysis, additional steam is likely being pulled into and condensing in the liquid extraction system; this steam extraction is not measureable and is not accounted for in condensate production**

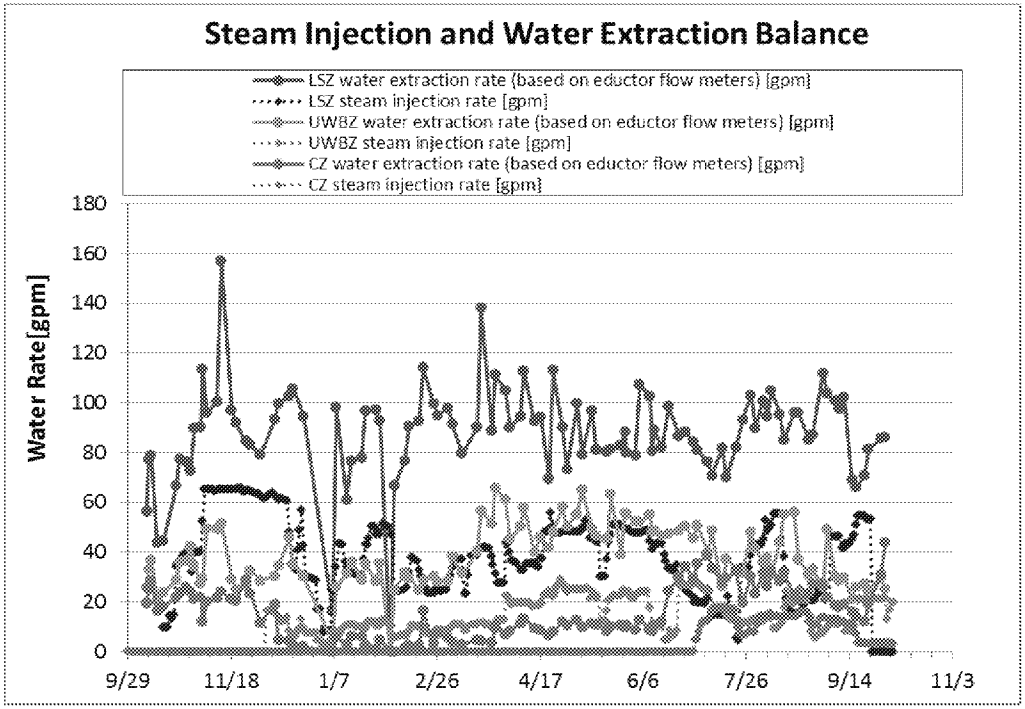
Site ST012 SEE System Water Extraction by Zone





- **Eductor extraction rates per zone are based on individual eductor feed and return meters**
- **Extraction: injection ratio for the week ending 5 October 2015: 5.4:1 based on average flows**
  - **CZ: 6.4:1 (8 September – 5 October 2015 period: 2.6:1)**
  - **UWBZ: 1.4:1 (8 September – 5 October 2015 period: 1.5:1)**
  - **LSZ: extraction rate 73 gpm, currently no steam injection (8 September – 5 October 2015 period: 2.4:1)**

Site ST012 SEE System Injection/Extraction Balance

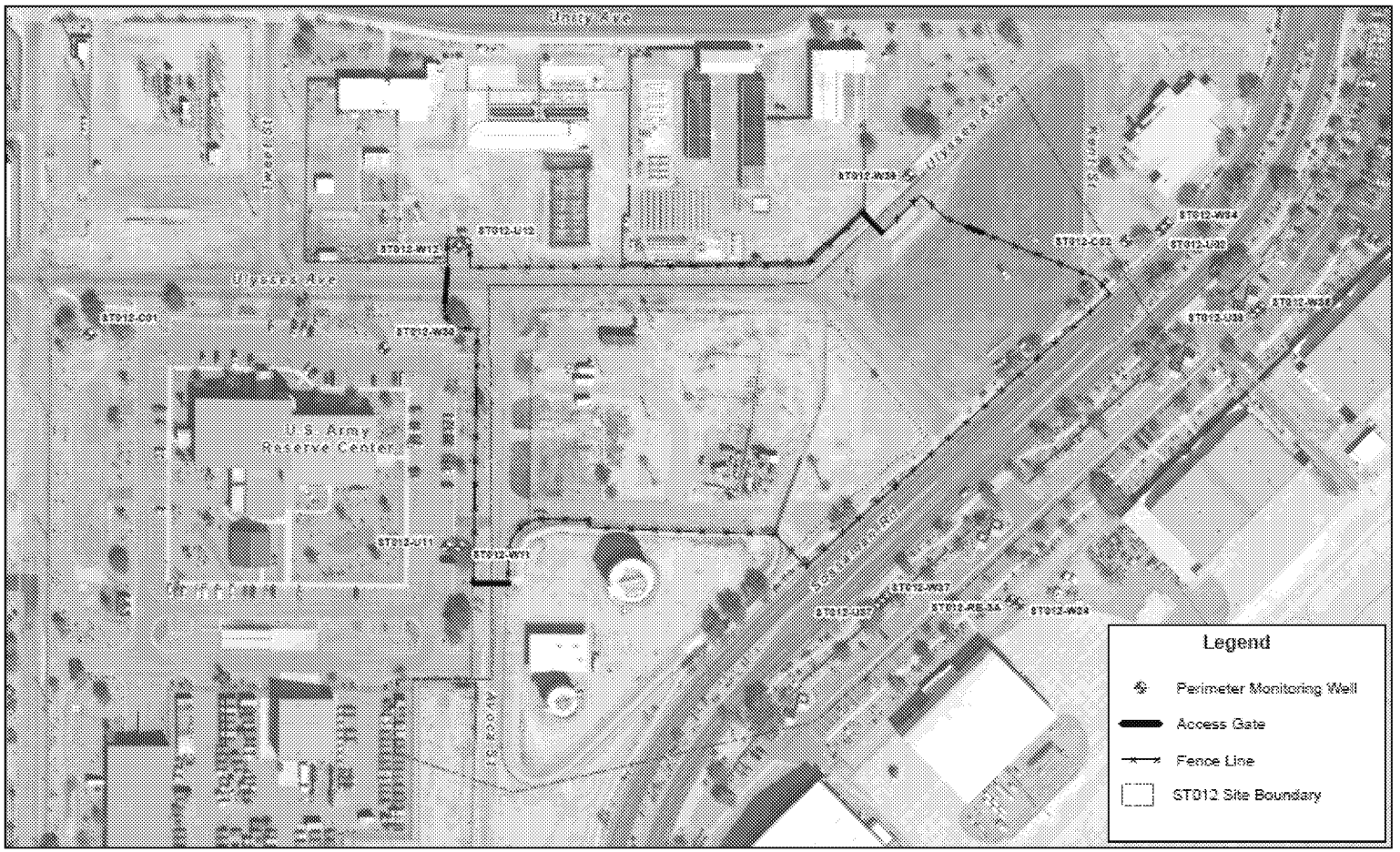


	CZ [gallons]	UWBZ [gallons]	LSZ [gallons]
Water extracted	7,837,000	19,542,000	45,015,000
Water injected (as steam)	1,570,000	6,573,000	19,278,000
Net extraction	6,267,000	12,969,000	25,737,000

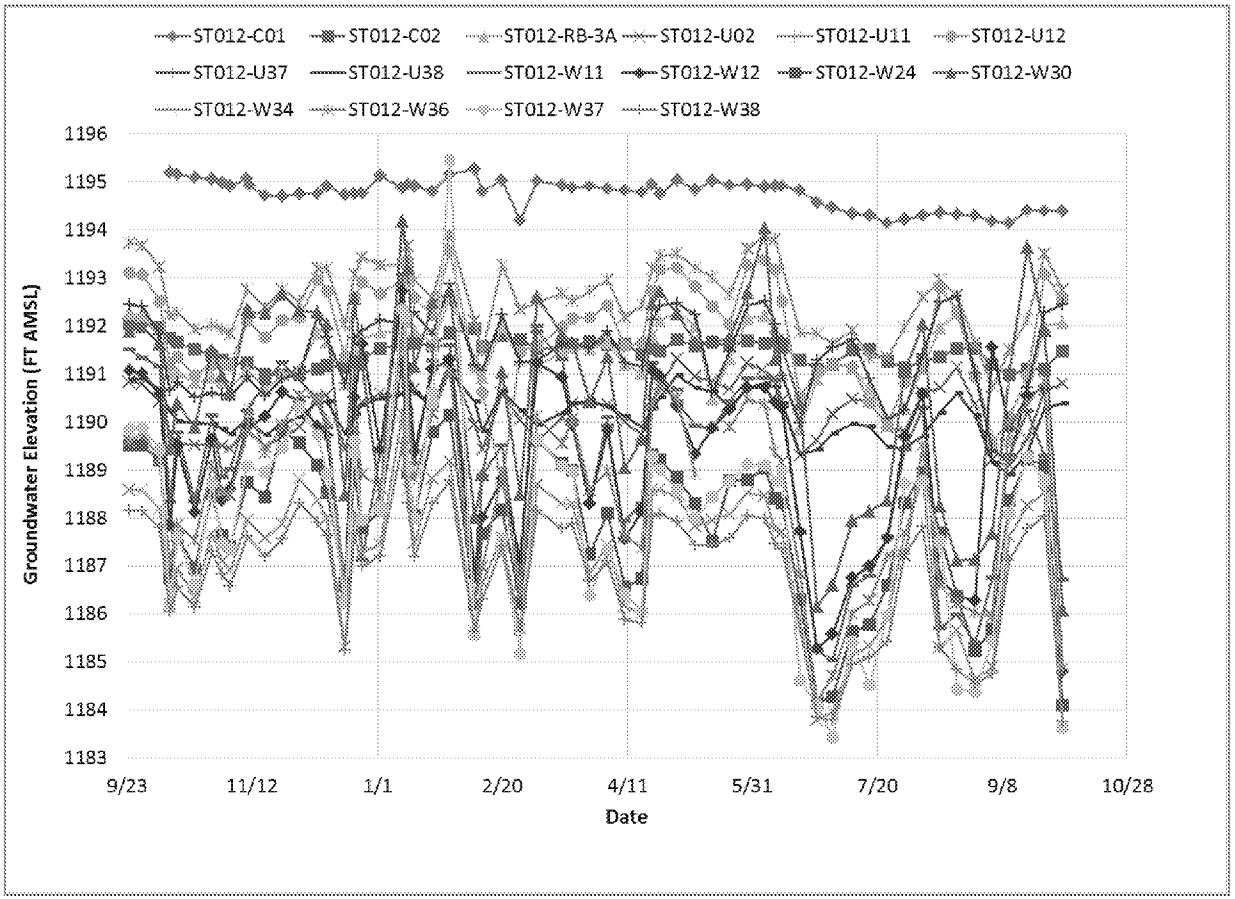
Note: water extracted to date per zone is based on individual eductor meters

ST012 Perimeter Groundwater Monitoring

Site ST012 SEE Perimeter Groundwater Monitoring Wells



Site ST012 SEE Perimeter Groundwater Elevations



Water level increases are temporary

Site ST012 SEE Perimeter
LNAPL Thicknesses (ft)

Monitoring Well	9/11/2015		9/18/2015		9/25/2015		10/2/2015	
CZ/UWBZ Wells	Before bailing	After Bailing	Before bailing	After Bailing	Before bailing	After Bailing	Before bailing	After Bailing
ST012-C01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ST012-C02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UWBZ Wells								
ST012-U02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ST012-U11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ST012-U12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ST012-U37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ST012-U38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ST012-RB-3A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LSZ Wells								
ST012-W11	13.30	0.27	0.10	0.10	50.23	0.12	31.59	11.24
ST012-W12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ST012-W24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ST012-W30	0.20	0.20	0.08	0.08	0.18	0.18	0.23	0.23
ST012-W34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ST012-W36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ST012-W37	81.25	2.35	52.19	0.38	97.21	26.43	82.85	20.85
ST012-W38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Site ST012 SEE Operational Plan

Operational Plan through November 2015

- **Pressure Cycling**
  - Continue pressure cycling in the CZ, UWBZ and LSZ
  - Continue steam injection into dual-purpose well UWBZ 20
  - Increase and optimize injection and extraction rates to maintain an acceptable water balance
- **Additional Operational Sampling**
  - Continue biweekly vapor influent sampling
  - Continue sampling select MPE wells to evaluate progress (evaluate and refine protocols)

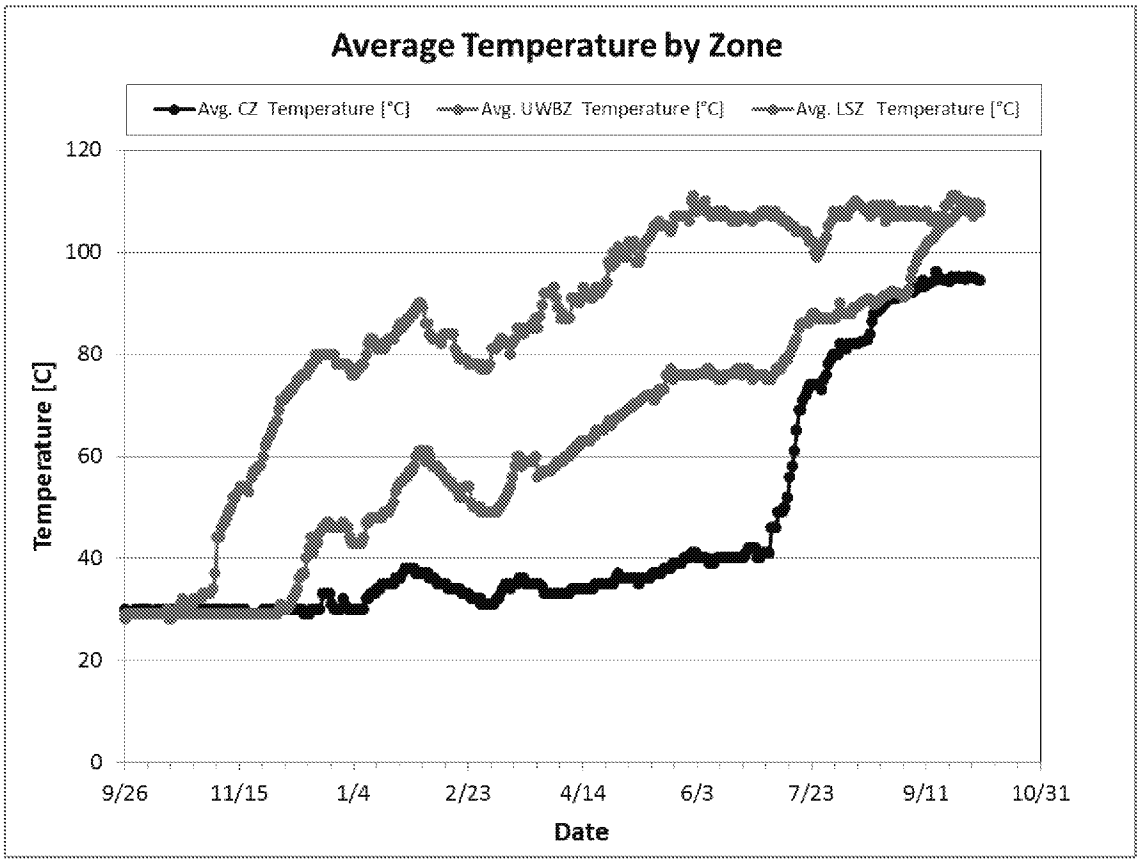
ST012 SEE to EBR Transition

Site ST012 SEE System
SEE to EBR Transition Criteria

- **Primary SEE to EBR Transition Criteria**
  - Achieve target subsurface temperatures
  - Diminishing mass removal rates
- **Secondary SEE to EBR Transition Criteria**
  - Completion of Pressure Cycling: Repeat until no additional significant increases in effluent vapor concentrations observed when steam pressure is reduced
  - Benzene Concentrations: Target benzene concentration of 100 to 500 µg/L range within the TTZ (interior of the TTZ)
  - Steam Injection: Used as a guideline to measure progress vs. design

Subsurface Temperature and Calculated Formation Temperatures

Site ST012 SEE
Average Temperatures by Zone



- **Average temperatures continue to increase in CZ and UWBZ**
- **LSZ temperature sensors 240 ft bgs and lower generally do not show steam temperatures**

CZ Target Treatment Temperature: ~100°C
UWBZ Target Treatment Temperature: ~114°C
LSZ Target Treatment Temperature: ~134°C

Estimated Formation Temperatures: Cobble Zone

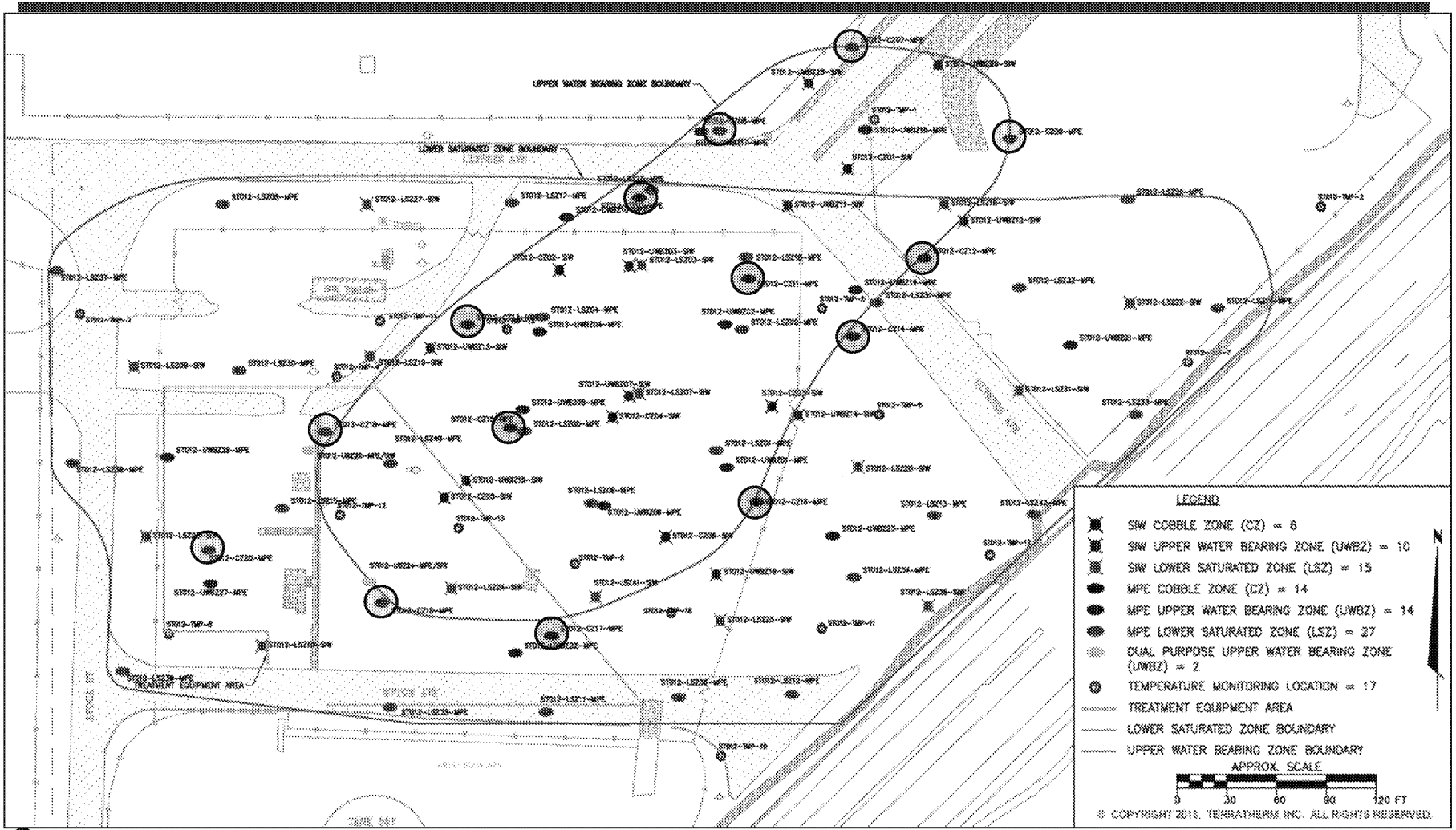
Well	Well	Required to Reach	Reached Steam	Vapor Extraction	Formation Temperatures																	
					8/3/15	8/5/15	8/7/15	8/11/15	8/13/15	8/18/15	8/20/15	8/25/15	8/27/15	9/1/15	9/3/15	9/7/15	9/9/15	9/11/15	9/15/15	9/17/15	9/21/15	9/23/15	9/29/15	10/1/15
	Location	Steam Temperature	Temperature (Calculated)	Max Temperature [°F]	[°F]	[°F]	[°F]	[°F]	[°F]	[°F]	[°F]	[°F]	[°F]	[°F]	[°F]	[°F]	[°F]	[°F]	[°F]	[°F]	[°F]	[°F]	[°F]
CZ07	Perimeter	No	No	131	106	141		127		143	138	161	152	148	163		159		152		137		167	155
CZ08	Perimeter	No	No	138	125	116		125		126	129	158	137		173		195		198		189		91	147
CZ09	Perimeter	No	No	105	113	117	121	118	120	107	115	110	117	130	109	132	98	139	104	168	96	138	139	159
CZ10	Perimeter	No	Yes	206	123	131		129		142	147	166	135		195		213		174		175		133	151
CZ11	Interior	Yes	Yes	212																				
CZ12	Perimeter	No	Yes	105	120	116	123	114	133	111	124	132	125	151	143	117	140	156	116	162	157	150	141	144
CZ13	Perimeter	No	Yes	160	157	151		176		161		149	158		160		167		168		>220		138	122
CZ14	Perimeter	No	Yes	112	123	>220	199	177	>220	212	217	>220	>220	191	136	185	>220	>220	211	196	>220	>220	>220	>220
CZ15	Interior	Yes	Yes	120	>220		172	163	214		>220	219	>220	>220	133	200	>220	162		195	>220	195	98	122
CZ16	Perimeter	No	Yes	117	170	>220	210	>220	>220	>220	>220	>220	>220	>220	>220	>220	>220	>220	198	>220	96	>220	132	158
CZ17	Perimeter	No	Yes	200	133	92	95	134	119	116	0	99	99		175	131	140	155	156	>220	181	136	133	148
CZ18	Perimeter	No	No	100	94	83	100	99		102	138	104	102		108	119		134	104	126		126		126
CZ19	Perimeter	No	No	110	91		95	110	103		107	136	137		150	139	148	128		148	115	145	134	135
CZ20	Outside CZ	No	No	111	100	89	100	99		99	109	89	94	96	91	95		101	83	92		99		97

RED : at or above steam temperature (≥210 °F)
GREEN : below steam temperature (<210 °F)

Liquid extraction has been disabled at CZ11 due to a well maintenance need. Consequently, formation temperatures could not be estimated. Vapor temperatures show steam breakthrough at CZ11.

Please note that the table has been truncated due to spatial constraints and only includes data from 3 August 2015 to present

Estimated Formation Temperatures: Cobble Zone



Estimated formation temperature or observed vapor temperature ≥210°F
Estimated formation temperature or observed vapor temperature < 210°F

Estimated Formation Temperatures: Upper Water Bearing Zone

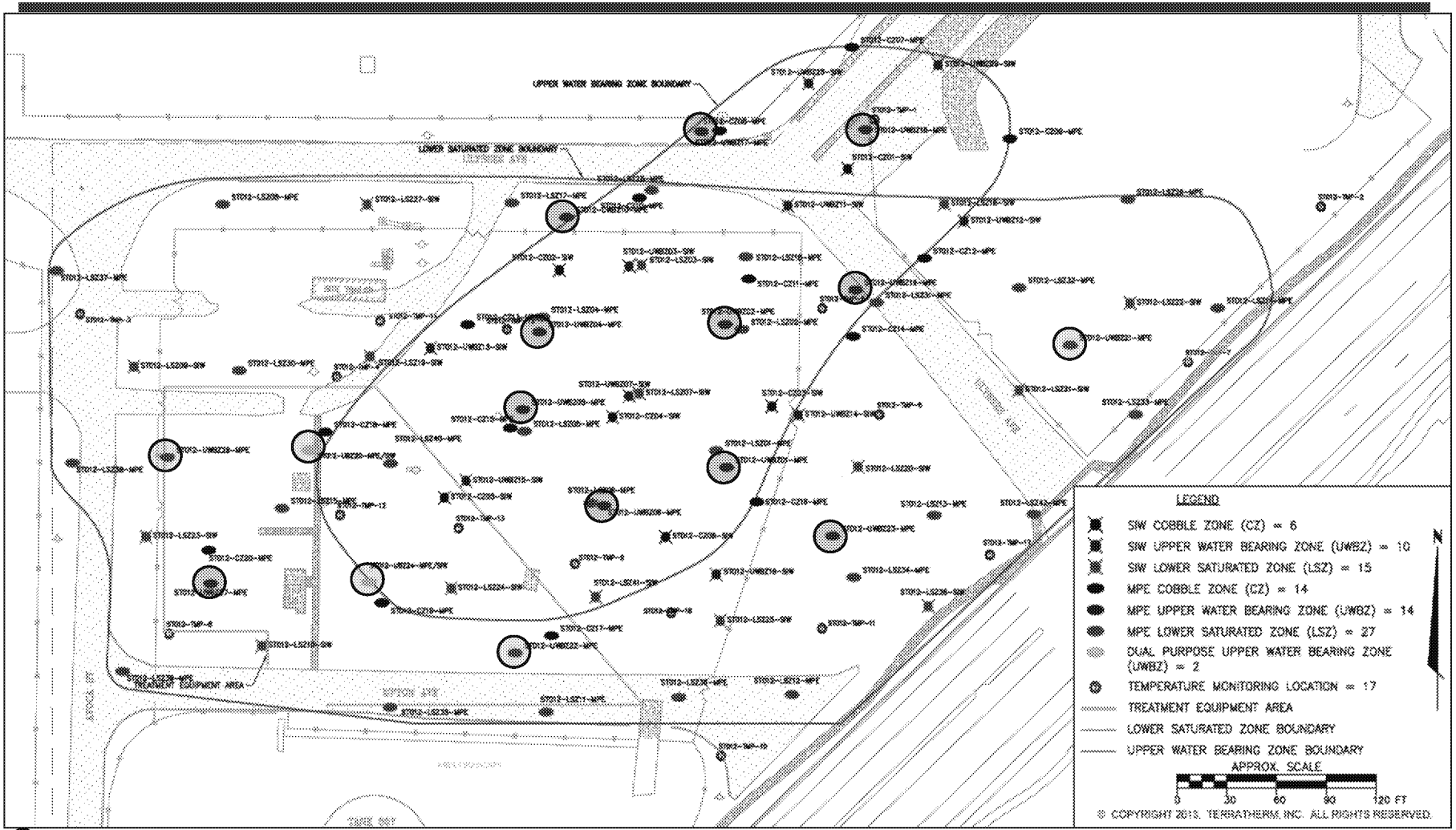
Well	Well	Required to Reach	Reached Steam	Vapor Extraction	Formation Temperatures																			
	Location	Steam Temperature	Temperature (Calculated)	Max Temperature [°F]	8/3/15 [°F]	8/5/15 [°F]	8/7/15 [°F]	8/11/15 [°F]	8/13/15 [°F]	8/18/15 [°F]	8/20/15 [°F]	8/25/15 [°F]	8/27/15 [°F]	9/1/15 [°F]	9/3/15 [°F]	9/7/15 [°F]	9/9/15 [°F]	9/11/15 [°F]	9/15/15 [°F]	9/17/15 [°F]	9/21/15 [°F]	9/23/15 [°F]	9/29/15 [°F]	10/1/15 [°F]
UWBZ01	Interior	Yes	Yes	150	>220	163	>220	175	202	215	>220	>220	>220	0	97		>220	>220	>220	77	>220	68	>220	>220
UWBZ02	Interior	Yes	Yes	160	>220		198	>220	>220		>220	>220	>220	>220	>220	>220	>220	>220	>220	165	>220	>220	>220	190
UWBZ04	Interior	Yes	Yes	168		191		166		111	>220	167	>220		143		146		145		>220		>220	
UWBZ05	Interior	Yes	Yes	220																196	>220	>220	>220	>220
UWBZ06	Interior	Yes	Yes	165	132	213	148	162	163	174	206	184	155	159	174	159	154	167	155	170	166	173	141	165
UWBZ10	Perimeter	No	Yes	133	166	179		164		196	192	219	126		172		170		>220		97		204	209
UWBZ17	Perimeter	No	Yes	220	196	205		>220		>220	>220	>220	>220		>220		>220		178		>220		162	>220
UWBZ18	Interior	Yes	Yes	180	97		144	191			>220	>220	>220	190	>220	182	>220	>220	>220	>220	194	156	>220	180
UWBZ19	Perimeter	No	Yes	146	>220	>220	>220	>220	>220	>220		>220	>220	>220	>220	>220	>220	>220	198	154	137	208	207	198
UWBZ20	Dual Phase - Perimeter	No	No	112	108	116	105	106		112	115	107												
UWBZ21	Outside UWBZ	No	No	118	169	169	210	186	164	164		108	114		103	153	154	141	141	129	166	171	172	165
UWBZ22	Perimeter	No	No	127	98	123	138	136	158	147		154	155		121	120	136	130	115	100	121	140	136	143
UWBZ23	Outside UWBZ	No	Yes	131	206	172	170	211	211	>220		>220	193		213	157	203	211	62	>220	214	219	215	171
UWBZ24	Dual Phase - Perimeter	No	No	190	98		100	125				93	92	133	153	107	158	109		154	110	125	150	111
UWBZ26	Outside UWBZ	No	No	105	129	135	124	130		116	118	105	96	113	112	81		137	122	122		128		123
UWBZ27	Outside UWBZ	No	Yes	115	>220	>220	209	>220	>220	195	>220	95	111	>220	>220	90		>220	88	201		>220		165

RED : at or above steam temperature (≥210 °F)

GREEN : below steam temperature (<210 °F)

Please note that the table has been truncated due to spatial constraints and only includes data from 3 August 2015 to present

Estimated Formation Temperatures: Upper Water Bearing Zone



Estimated formation temperature or observed vapor temperature ≥210°F

Estimated formation temperature or observed vapor temperature < 210°F

Estimated Formation Temperatures: Lower Saturated Zone

Well	Well	Required to Reach	Reached Steam	Vapor Extraction	Formation Temperatures																		
	Location	Steam Temperature	Temperature (Calculated)	Max Temperature [°F]	8/3/15 [°F]	8/5/15 [°F]	8/7/15 [°F]	8/11/15 [°F]	8/13/15 [°F]	8/18/15 [°F]	8/20/15 [°F]	8/25/15 [°F]	8/27/15 [°F]	9/1/15 [°F]	9/3/15 [°F]	9/7/15 [°F]	9/9/15 [°F]	9/11/15 [°F]	9/15/15 [°F]	9/17/15 [°F]	9/21/15 [°F]	9/23/15 [°F]	9/29/15 [°F]	10/1/15 [°F]
LSZ01	Interior	Yes	Yes	126	181	192	180	153	200	>220	146	107	107	130	184	157	183	182	113	132	174	194	194	193
LSZ02	Interior	Yes	Yes	130			186	186	101				117	166	189	74				>220	>220	>220	>220	191
LZS04	Interior	Yes	Yes	206*																				93
LSZ05	Interior	Yes	Yes	220	>220		>220	>220	>220		150	>220		75	80	213	>220	>220	>220	76	95	>220		
LSZ06	Interior	Yes	Yes	218	>220	>220	>220	>220	>220	205	204	188	198	>220	187	191	217	216	>220	>220	96	>220	>220	>220
LSZ08	Perimeter	No	Yes	120	199	>220		129		205	207	196	>220	209	205		202		107		>220		144	212
LSZ11	Perimeter	No	Yes	119		>220		>220	>220		>220	>220	>220	99	0	>220	>220			0	104			
LSZ12	Perimeter	No	No	126	177	181	189	191	190	178	163	168	168	159	172	174	175	165	171	183	168	192	192	170
LSZ13	Interior	Yes	Yes	125	203	216	203	206	212	194	0	199	203		189	190	201	158	179	198	220	199	205	218
LSZ14	Perimeter	No	No	125	192	185	195	190	193	183	174	176	177	161	165	172	180	186	185	185	190	196	185	169
LSZ15	Interior	Yes	Yes	205*	>220	>220	>220	>220		>220	125	209	207	155	>220	>220		>220	>220	>220		>220		212
LSZ16	Interior	Yes	Yes	205*	158		162	173			169	163	>220	157	158	182	186	191		176	107	200	160	160
LSZ17	Perimeter	No	Yes	220											140		165		98		171		120	119
LSZ28	Perimeter	No	Yes	129	193	209		>220		0	188	171	184		164		178		177		185		0	167
LSZ29	Perimeter	No	No	116	167	190	161	104	170	190	0	175	186		165	155	167	159	59	195	179	190	167	184
LSZ30	Interior	Yes	Yes	133	217	>220	219	211		209	213	189	210	212	201	211		217	215	215		214		>220
LSZ31	Interior	Yes	Yes	147	214	>220	>220	>220	>220	220	215	208	197		97	173	186	187	176	188	202	208	191	175
LSZ32	Interior	Yes	Yes	120	>220	217	201	209	219	202	0	201	213		167	175	197	195	208	163	206	195	215	202
LSZ33	Perimeter	No	Yes	130	193	199	200	>220	207	195	191	193	199	178	184	178	185	182	105	193	166	198	192	192
LSZ34	Interior	Yes	Yes	128	190	205	200	213					118		113	162	192	127	121	124	192	207	120	171
LSZ35	Perimeter	No	Yes	121		124	143	135	145	204	127	168	>220	202	119	114	119	130	117	116	107	133	124	117
LSZ36	Perimeter	No	Yes	128	175	183	196	194	202	195	190	183	182	177	177	178	180	171	119	193	213	207	193	192
LSZ37	Perimeter	No	Yes	208*	213	>220	>220	>220		171	141	127	123	91	144	172		200	194	200		216		176
LSZ38	Perimeter	No	Yes	116	147	151	150	161		144	156	137	146	153	163	153		150	134	175		165		161
LSZ39	Perimeter	No	No	118	124	132	127	132		117	113	101	102		112	108		126	116	117		135		135
LSZ40	Interior	Yes	Yes	135	>220		>220	>220	>220		217	200	198	200	193	208	210	216	>220	209	>220	>220	>220	>220
LSZ42	Perimeter	No	Yes	130	163	182	190	194	190	188	192	195	193	181	183	103	193	183	102	184	166	190	194	180

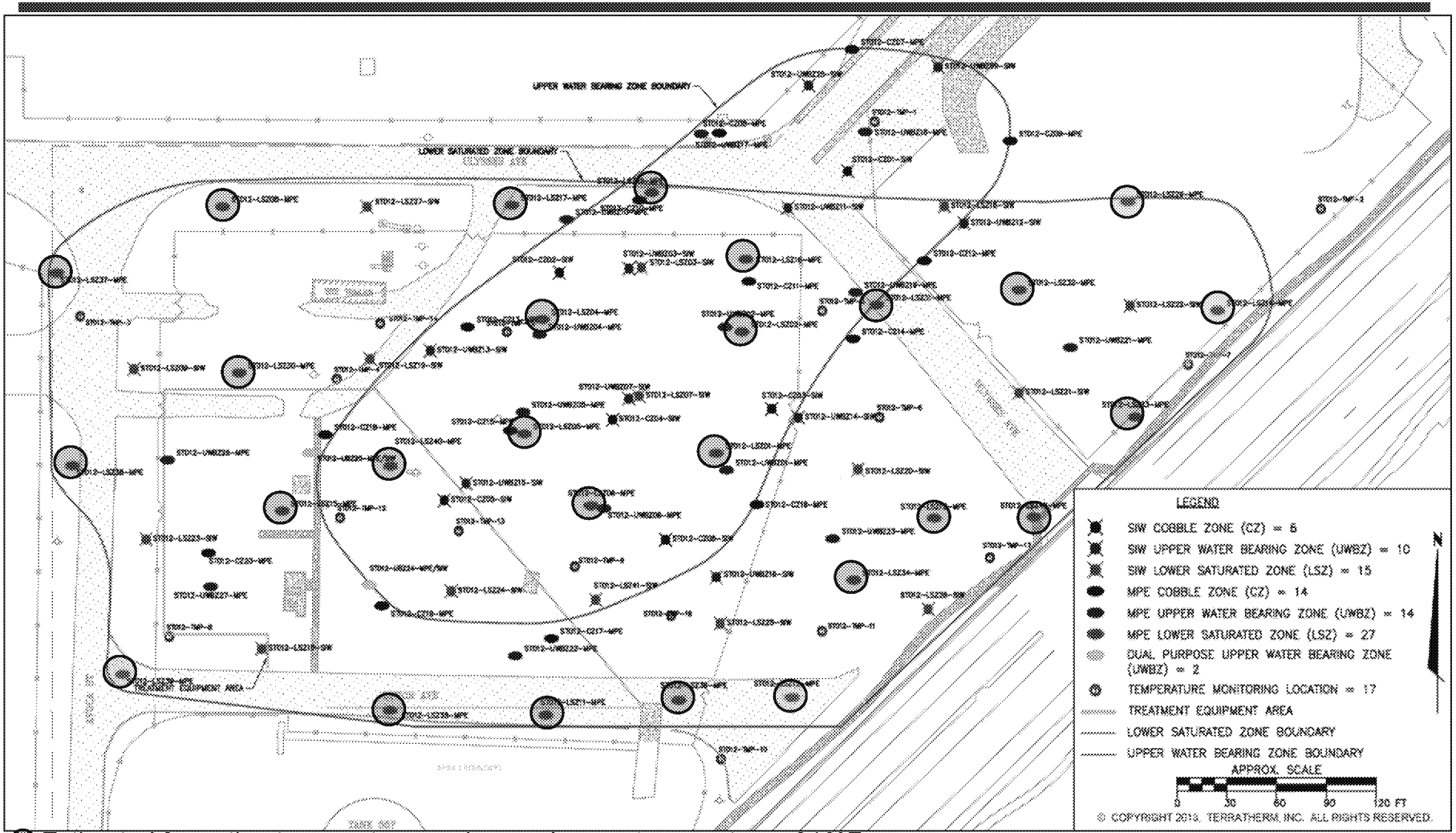
RED : at or above steam temperature (≥210 °F)

GREEN : below steam temperature (<210 °F)

**Highlighted vapor extraction temperatures below 210°F assumed to have been at steam temperature at depth*

Please note that the table has been truncated due to spatial constraints and only includes data from 3 August 2015 to present

Estimated Formation Temperatures: Lower Saturated Zone



Estimated formation temperature or observed vapor temperature ≥210°F
Estimated formation temperature or observed vapor temperature < 210°F

Pressure Cycling and Mass Removal

Pressure Cycling Status

- **Operational data reviewed to determine initiation of pressure cycling:**
  - **Multi-phase Extraction (MPE) Well Vapor Extraction Temperature**
  - **Temperature Monitoring Point Data**
  - **Calculated MPE Well Formation Temperature**

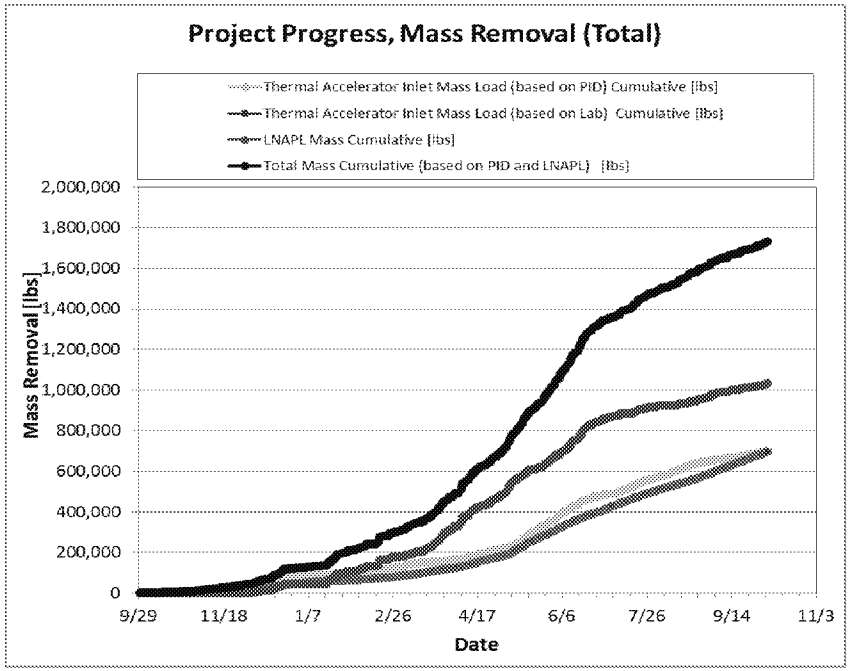
- **Pressure Cycling Status by Zone:**

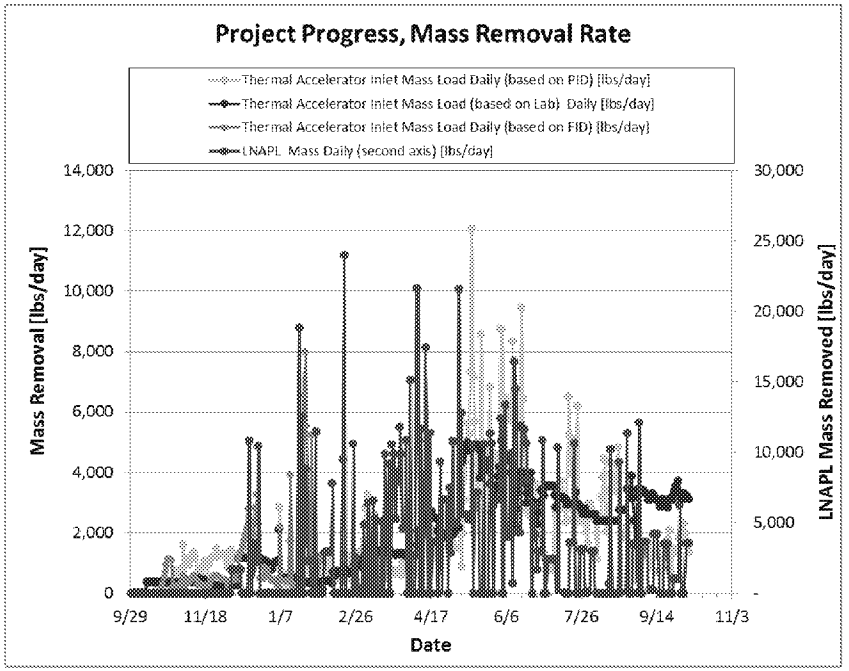
CZ			6/30/2015					9/17/2015	
UWBZ		12/4/2014	6/8/2015	6/22/2015	7/24/2015	8/12/2015	8/26/2015	9/17/2015	
LSZ	10/16/2014		6/16/2015		7/24/2015	8/12/2015	9/4/2015		9/25/2015

Pressurization
Depressurization

**Please note that dates in the table above are the dates that pressurizations or depressurizations were initiated*

Site ST012 SEE System Mass Removal

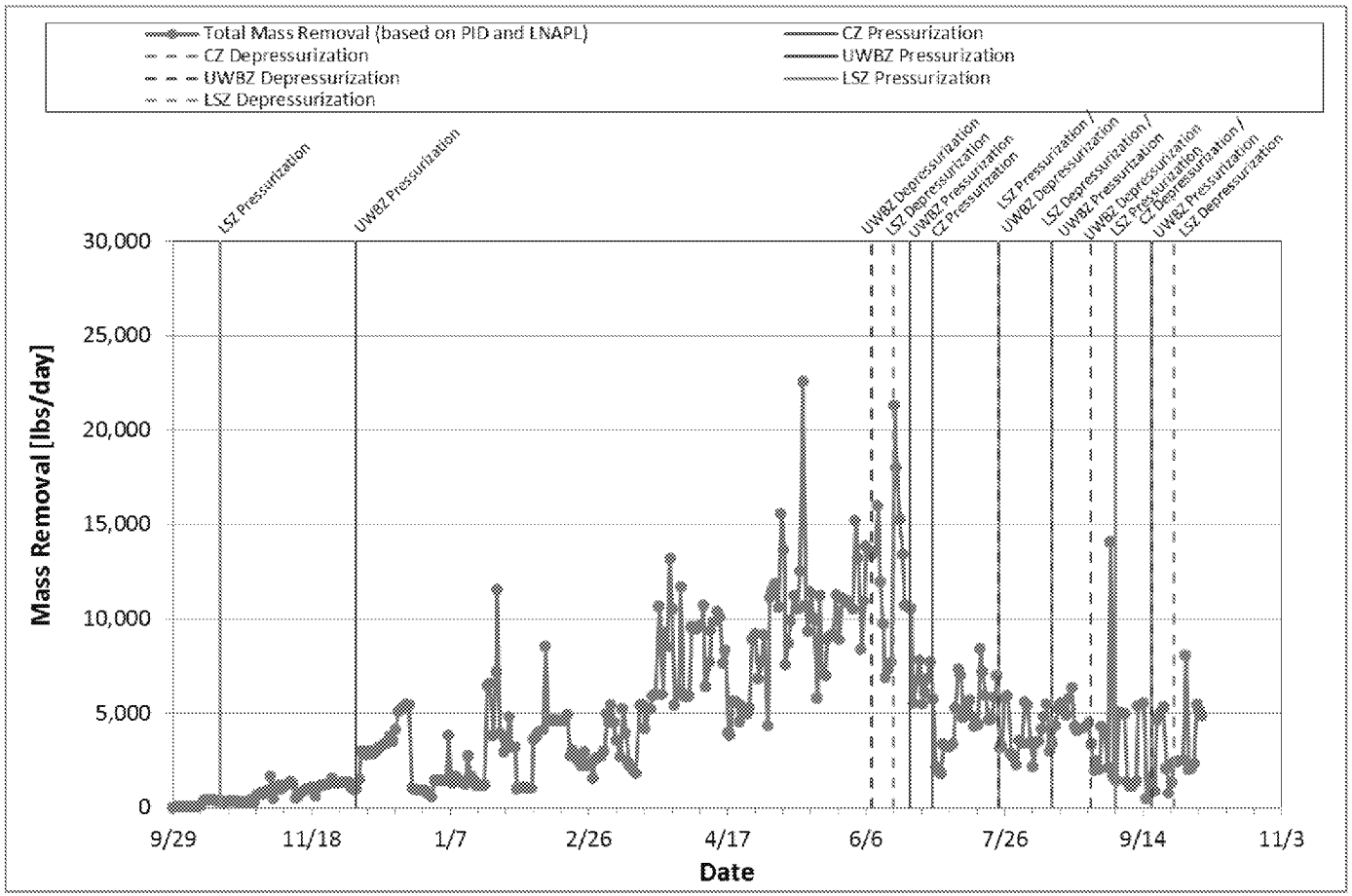




- **Total Contaminant Mass Removal: 1,730,578 lbs recovered**
- **An estimated 1,031,501 lbs (156,763 gallons) as non-aqueous phase liquid (NAPL)**
- **An estimated 699,078 lbs of mass (PID) removed in the vapor phase (equivalent to 106,242 gallons)**

Pressure Cycling and Mass Removal

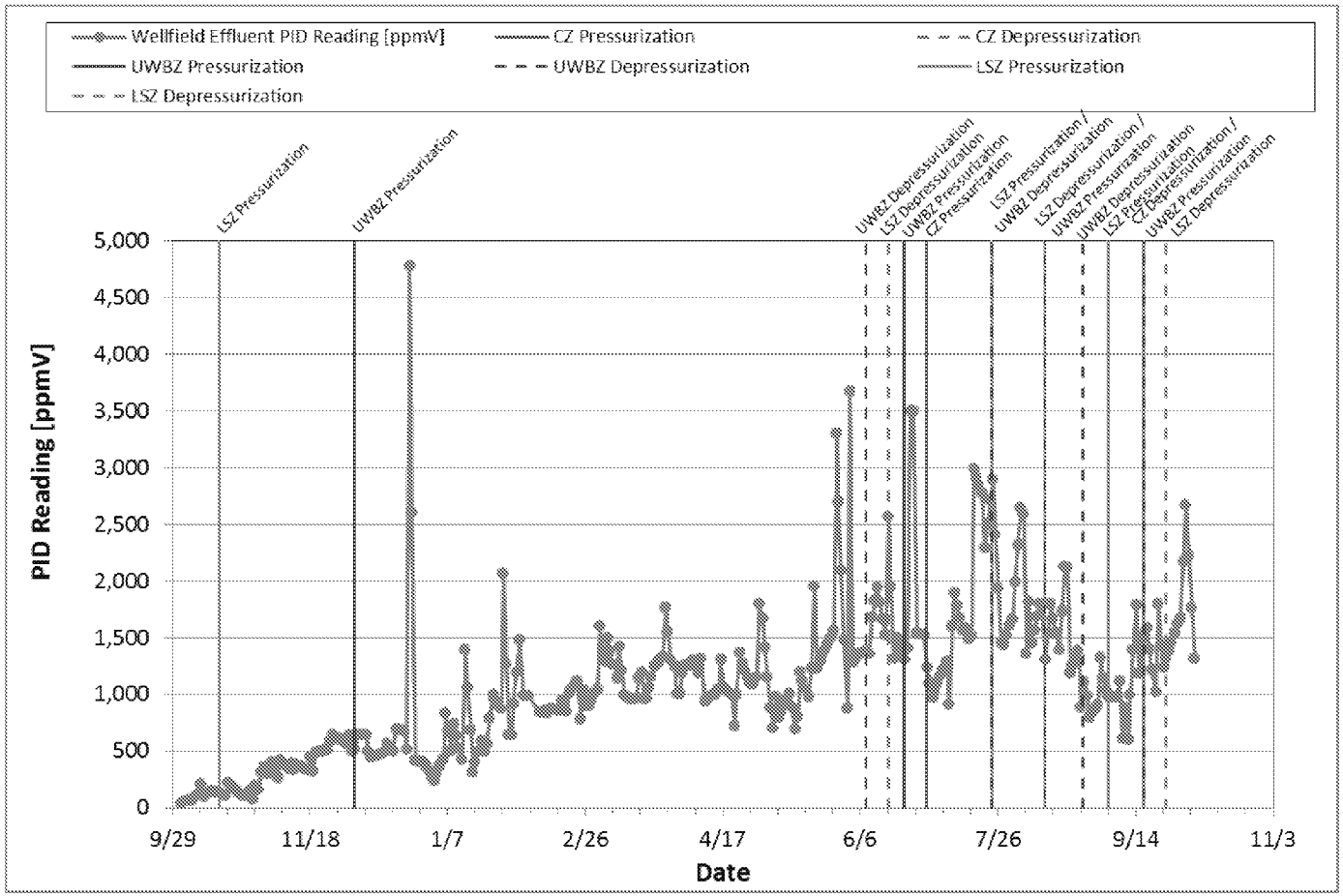
Mass Removal over Time



- **Peak mass removal occurred April – June 2015 (vapor and NAPL phases)**

Pressure Cycling and Vapor Mass Removal

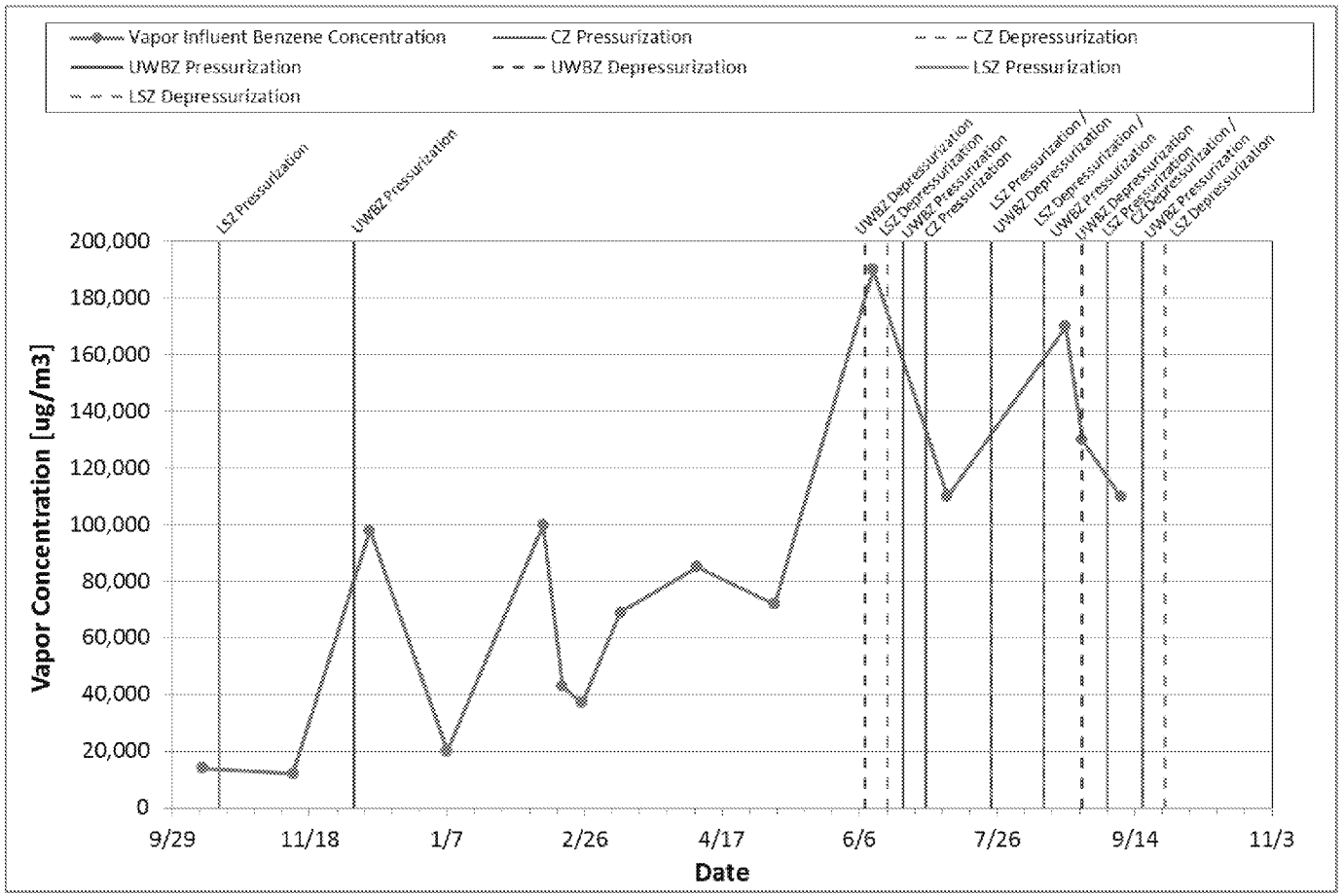
Wellfield Vapor Influent PID Concentrations over Time



- **Vapor phase removal has increased after initiation of pressure cycling**

Pressure Cycling and Benzene Vapor Mass Removal

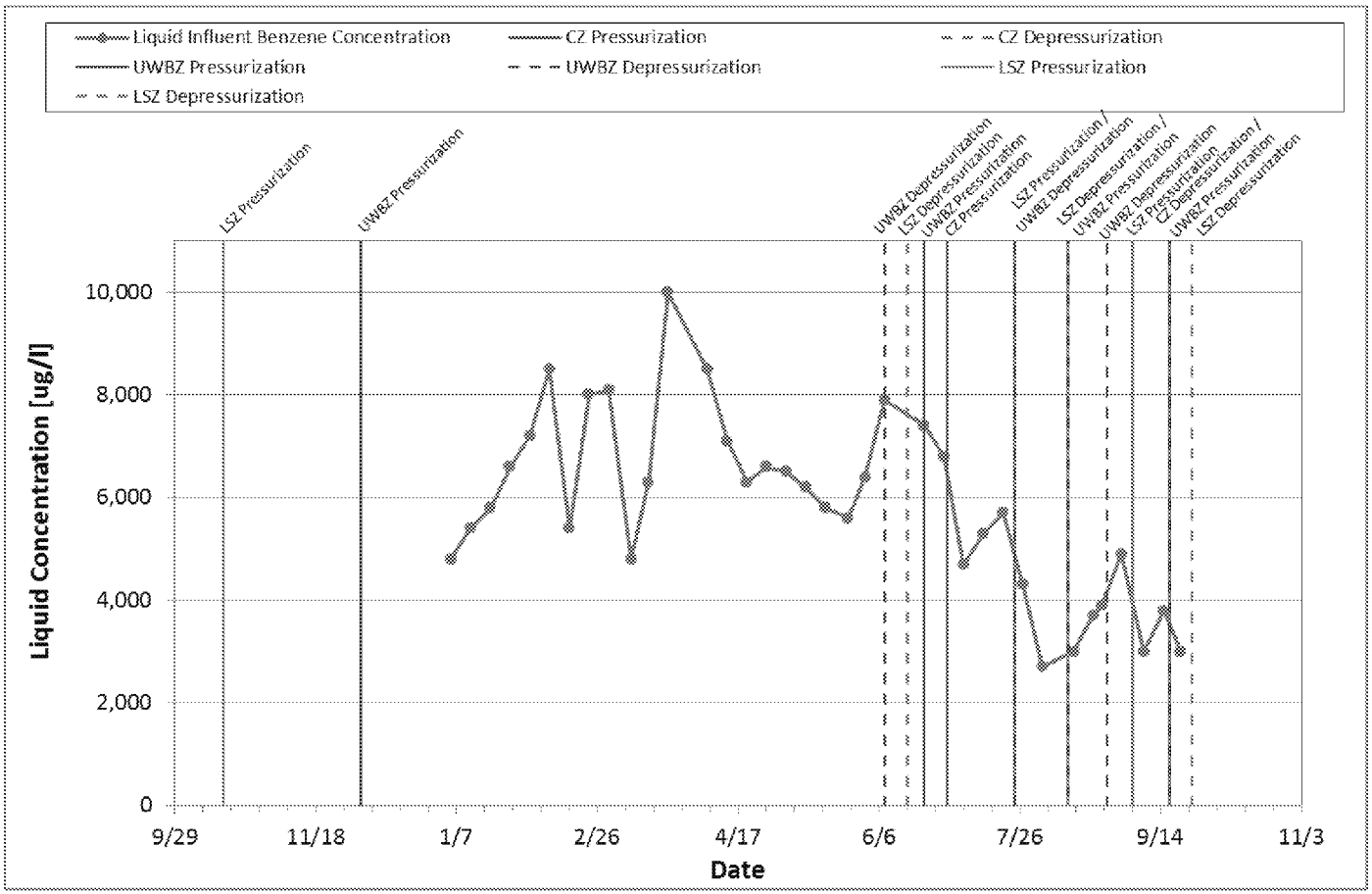
Extracted Vapor Benzene Concentrations over Time
(measured at thermal accelerator influent [includes air stripper effluent] by EPA Method TO-15)



- **Benzene concentrations have peaked during depressurization events**

Pressure Cycling and Benzene Liquid Mass Removal

Extracted Liquid Benzene Concentrations over Time (measured at air stripper influent by EPA Method 8260B)



- **Dissolved phase benzene concentrations have declined from the peak**

Benzene Concentrations in Groundwater

Groundwater Sampling Background

- **Primary Purpose: Provide initial screening level benzene concentrations throughout the CZ, UWBZ and LSZ**
- **Benzene concentrations estimated at each MPE well location**
  - **Inputs: Motive Water Flow Rate; Motive Water Benzene Concentration; Return Water Flow Rate; and Return Water Benzene Concentration**
  - **Estimates:**
    - **Groundwater Extraction Rate (based on difference between motive and return flow)**
    - **Groundwater Concentration (based on mass balance calculation)**

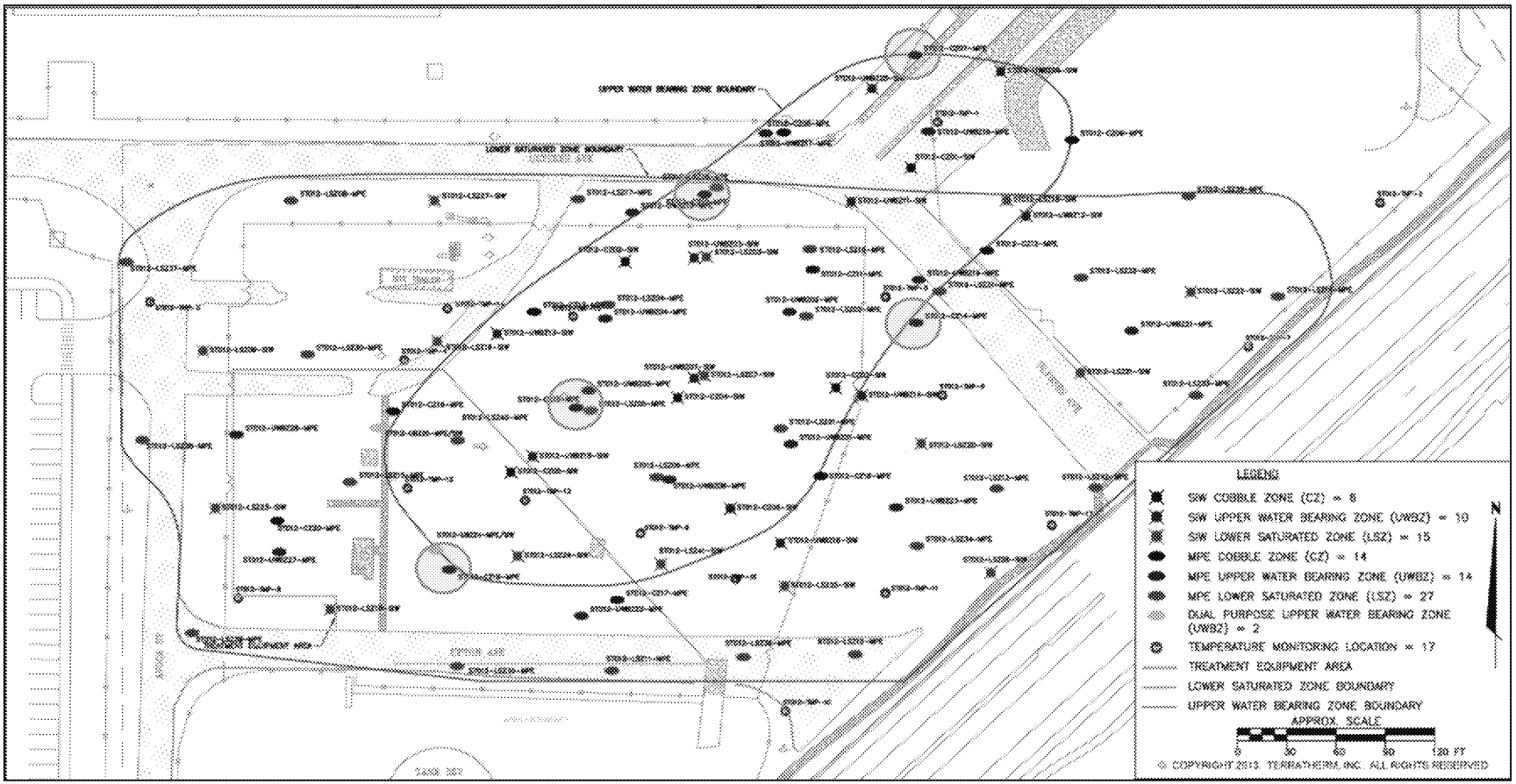
Groundwater Sampling Background

- **Variability noted between sampling rounds**
- **Factors affecting concentration estimation**
  - **Flow meter accuracy**
  - **Motive water concentration**
    - **Representative of overall conditions (mix of CZ, UWBZ, and LSZ)**
    - **Includes variability of benzene concentration depending on SEE operations (e.g., current pressurization/depressurization status in each zone)**
    - **Includes contribution of groundwater from outside the TTZs**
  - **Capture and condensation of steam in the liquid stream**

Groundwater Sampling Background

- **Refinement of current sampling approach to reduce variability:**
  - **Sampling after system is isolated to one zone (allows motive water to equilibrate to one zone)**
  - **Sampling after vapor extraction line has been turned off (reduces potential steam capture and condensation in the liquid stream)**
- **Testing alternative sampling approach**
  - **Using bailers/other direct pumping methods (more direct measurement of groundwater)**
    - **Requires well shutdown and wellhead removal**
    - **Eductor and piping may hinder sample collection**

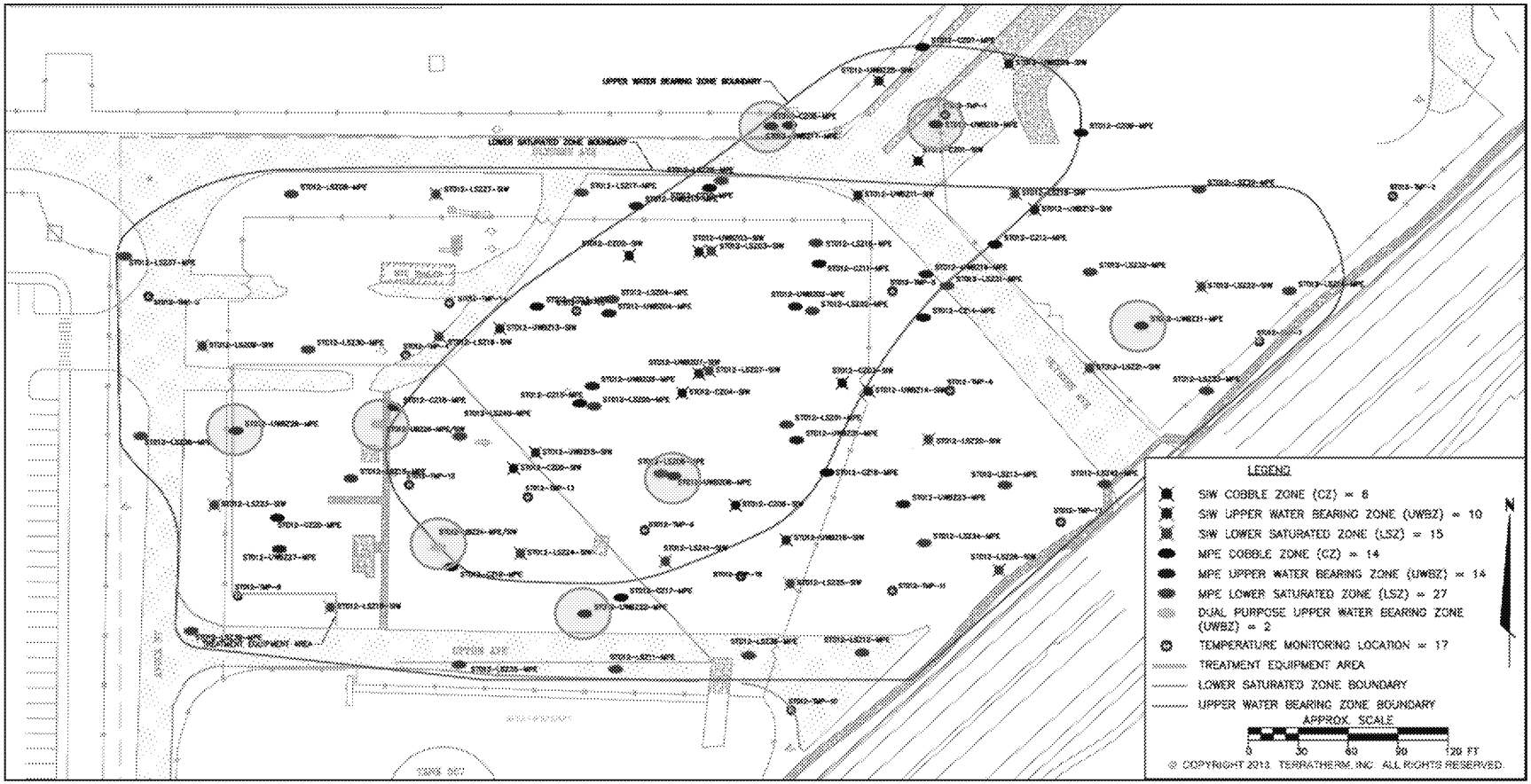
11-12 August Groundwater Sampling Benzene Results - CZ



Benzene concentrations:

- **<500 ug/L**
- **500-2,000 ug/L**
- **>2,000 ug/L**

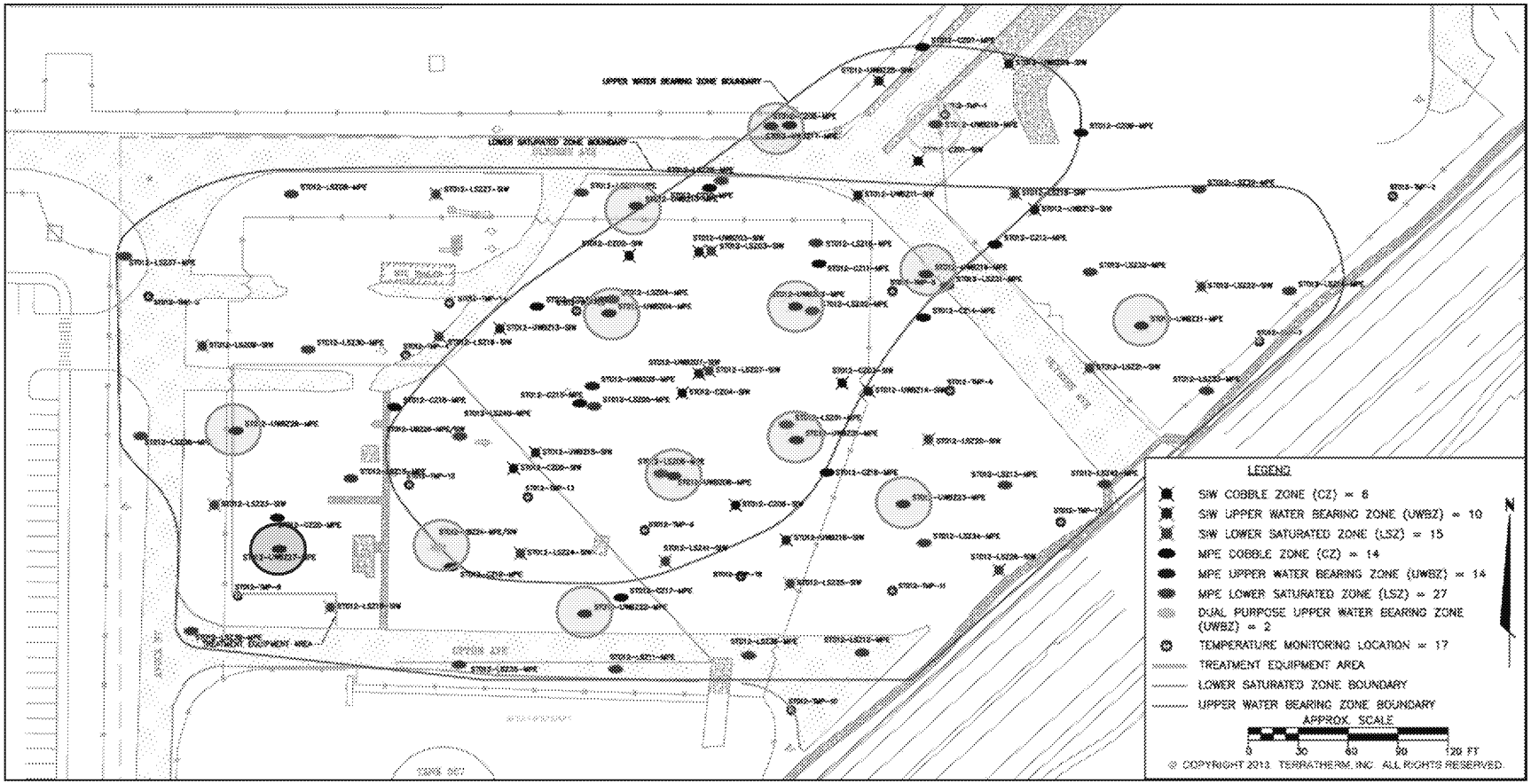
11-12 August Groundwater Sampling Benzene Results - UWBZ



Benzene concentrations:

- **<500 ug/L**
- **500-2,000 ug/L**
- **>2,000 ug/L**

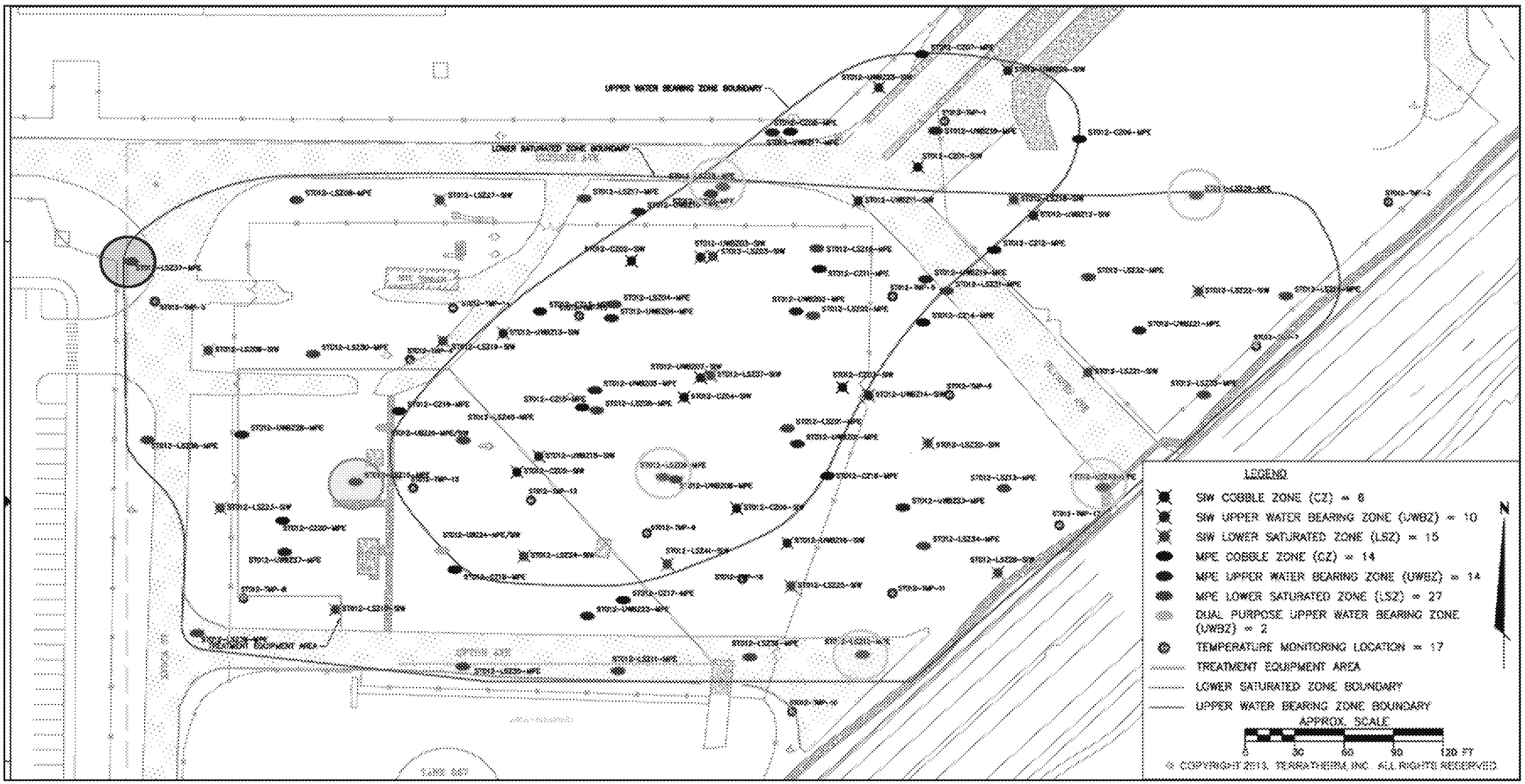
8 September Groundwater Sampling Benzene Results - UWBZ



Benzene concentrations:

- **<500 ug/L**
- **500-2,000 ug/L**
- **>2,000 ug/L**

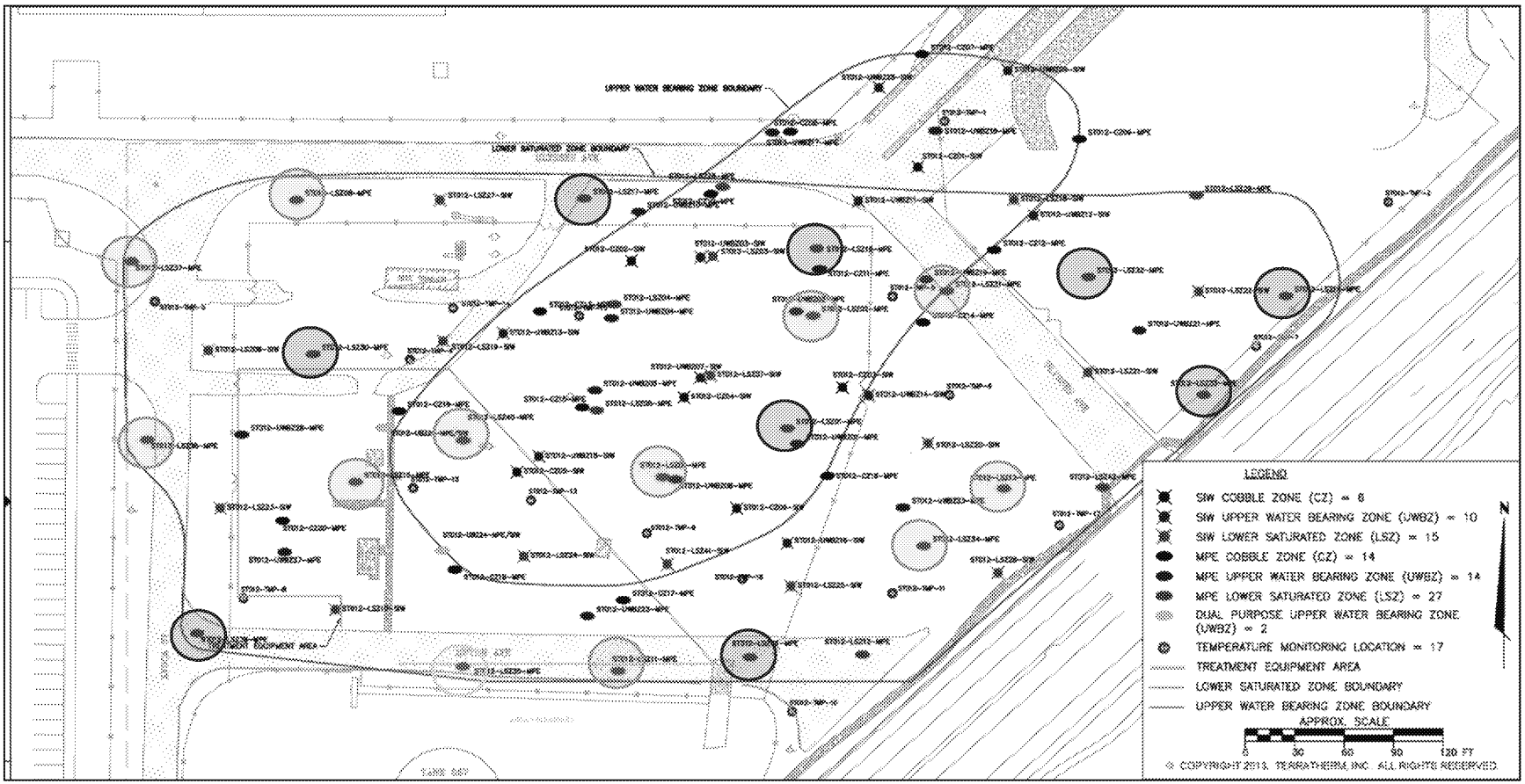
11-12 August Groundwater Sampling Benzene Results - LSZ



Benzene concentrations:

- **<500 ug/L**
- **500-2,000 ug/L**
- **>2,000 ug/L**

1-2 September Groundwater Sampling Benzene Results - LSZ



Benzene concentrations:

- **<500 ug/L**
- **500-2,000 ug/L**
- **>2,000 ug/L**

Steam Injection and Energy Balance

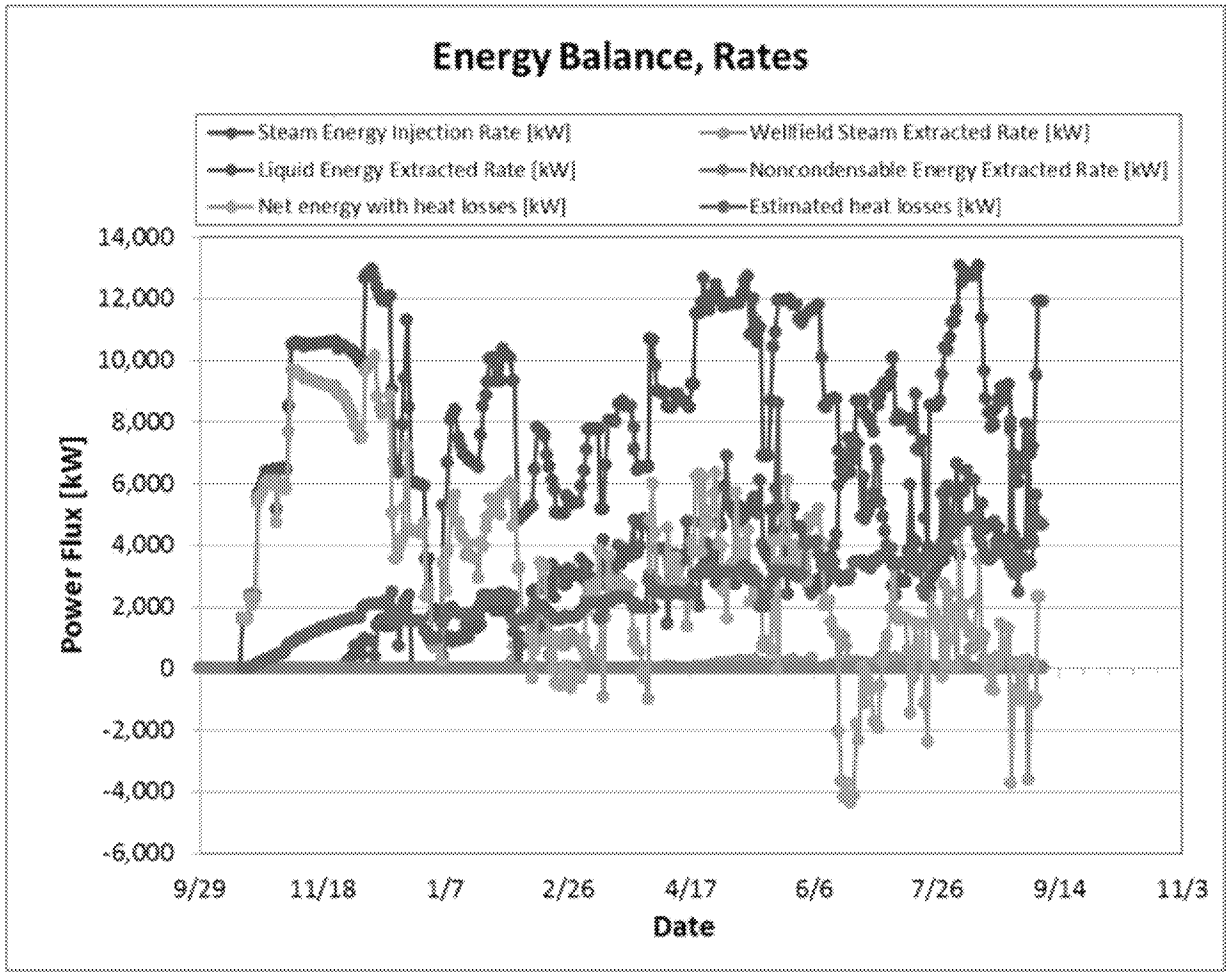
Site ST012 SEE System Energy Balance

Energy Balance Updates

- **TerraTherm's Energy Balance has been updated to include calculated heat losses**
- **Heat losses are a combination of heat lost below the TTZ, above the TTZ and outside the TTZ**
- **Approach:**
  - **Based on the original SEE model, cumulative modeled heat losses were calculated for each operational phase (i.e., heat up, pressure cycling)**
  - **The heat losses were compared to the cumulative energy added as steam for each operational phase**
  - **The percent of total steam energy "lost" was calculated by comparing modeled heat losses to modeled steam injection**
  - **Since the actual steam injection rates at ST012 have been different than originally modeled, the percent heat loss calculated for each operational phase in the model was applied to the actual steam injected to get the calculated heat losses during operation**
  - **The calculated heat losses during operation are subtracted from the net energy injected to determine the "net energy with heat losses" shown on the Energy Balance figures**

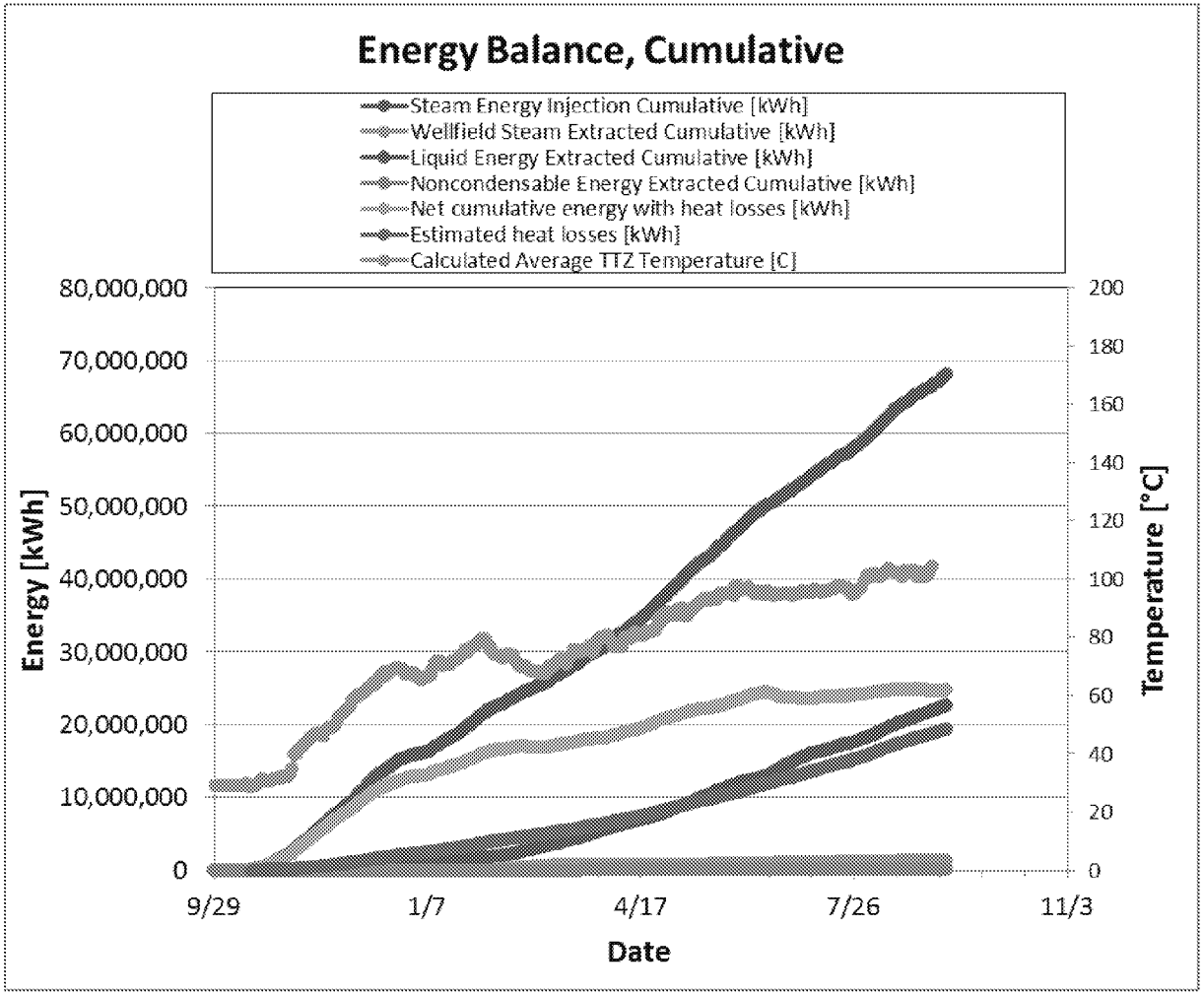
Site ST012 SEE System Energy Balance

- Heat losses (kW) increase as the site heats up - as the steam bubble expands, the surface area of the heated area increases and so do the associated heat losses
- During recent pressure cycling events, the heat losses stayed relatively stable
- During the pressure cycling phase the temperature is stable (except in some areas of the TTZ where heat up is still active) and the net energy is close to zero



Site ST012 SEE System Energy Balance

- Net energy injected was positive in the heat up phase
- Cumulative net energy injection is more or less flat during pressure cycling – as much energy is extracted as injected



Site ST012 SEE System
SEE to EBR Transition Criteria Progress

Transition Criteria	Progress
Target Temperature Achievement	CZ: Average target temperature achieved with the exception of TMP 12 UWBZ: Average target temperature achieved LSZ: Average temperature in LSZ above 235 ft bgs is 115˚C Steam breakthrough observed at all interior MPE wells
Pressure Cycling Status	CZ: Currently in the initial depressurization, pending pressurization UWBZ: Currently in the fourth pressurization/depressurization cycle LSZ: Currently in the third pressurization/depressurization cycle
Mass Removal Status	Peak mass removal occurred April – June 2015 (vapor and NAPL phases)
Benzene Concentrations	Overall decline in dissolved phase benzene concentrations Groundwater sampling events scheduled to refine benzene distribution
Steam Injection Status	~228 MM lbs of steam injected – energy balance shows temperatures currently being maintained and some areas still targeted for heat up

Site ST012 SEE System Path Forward

- Primary transition criteria met (subsurface temperatures and mass removal). Pressure cycling mass removal also diminishing (secondary transition criteria). Focusing on further groundwater concentration status.
- Additional sampling and projected end of steam injection:
  - 16 Oct – Receive round of UWBZ MPE well samples collected with vapor off. Refine final sampling approaches
  - Week of 19 Oct – Receive latest round of LSZ MPE well samples by direct collection method (bailer/foot valve apparatus). Refine final sampling approaches
  - Week of 26 Oct – collect groundwater samples in the LSZ
  - Week of 2 Nov – collect groundwater samples in the UWBZ and CZ
  - Week of 9 Nov – Receive and compile data
  - Week of 16 Nov – Review and discuss shutdown (BCT meeting)
  - 20 Nov – Shutdown of steam
- Sample planning is dynamic in response to results received at each round. Changes are likely.

Site ST012 SEE System Benzene Concentrations

- Groundwater concentrations above 500 µg/L expected to remain at TTZ perimeters because of known contamination outside of TTZ (predicted in Work Plan).
- Contribution from perimeter likely enhanced by elevated temperatures (increased dissolution and solubility, predicted in Work Plan)).
- Groundwater concentrations may also be above 500 µg/L in some areas of TTZ interior because of contribution from perimeter groundwater (i.e., extracted groundwater at interior MPE wells originates as a combination of condensed steam and perimeter groundwater pulled to the interior)
- 100 to 500 µg/L was set as the goal for SEE in the interior based on the ability of continued biodegradation following EBR to achieve MCLs ~20 years post ROD
- Concentrations above 500 µg/L in the TTZ can be addressed through EBR:
  - Depletion of LNAPL in TTZ interior leaves mainly dissolved phase BTEX
  - Sulfate injected at perimeter will migrate and contribute to reductions in TTZ interior
  - EBR treatment of perimeters will reduce further perimeter contributions to TTZ interior
  - Post-SEE dissolved phase concentrations will be evaluated and sulfate injections within the TTZ can be performed, if necessary.